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FRACTURES OF THE HIP: A METHOD FOR MORE POSITIVE STABILIZATION—PRELIMINARY REPORT OF 15 CASES

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During recent years various papers have been published bearing on the apparent desirability of producing an over-reduced position in fractures of the hip. Most of these reports have dealt with the intracapsular fracture types, and the method of producing what amounts to an "abduction" fracture in stable position has varied somewhat. McElvenny[5] uses a high degree of traction on the fracture table to over-reduce the fracture and place the small beaklike spur on the inferior surface of the proximal fragment within the cervical intramedullary canal; thus he produces a mechanically stable situation. Others reduce the fracture anatomically and then with a sharp blow over the greater trochanter convert the fracture into an impacted abduction type, which type experience has shown to be a much more likely candidate for uncomplicated union. These preliminary maneuvers are then followed by fixation with one of a variety of nails or pins depending on the preference of the surgeon. This paper is concerned with the merits of the positional change noted above and with the over-reduction principle; the merits of various lag screws and sliding nails are not within the province of this discussion except as their development points up the problem of the "unsolved fracture" and the fact that the percentage of nonunion or eventual aseptic necrosis has previously remained between 15 per cent and 34 per cent depending, as in the latter figure, on whether the cases are followed long enough.[1, 2]

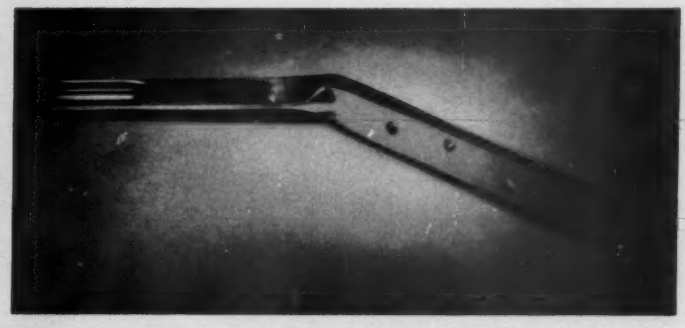
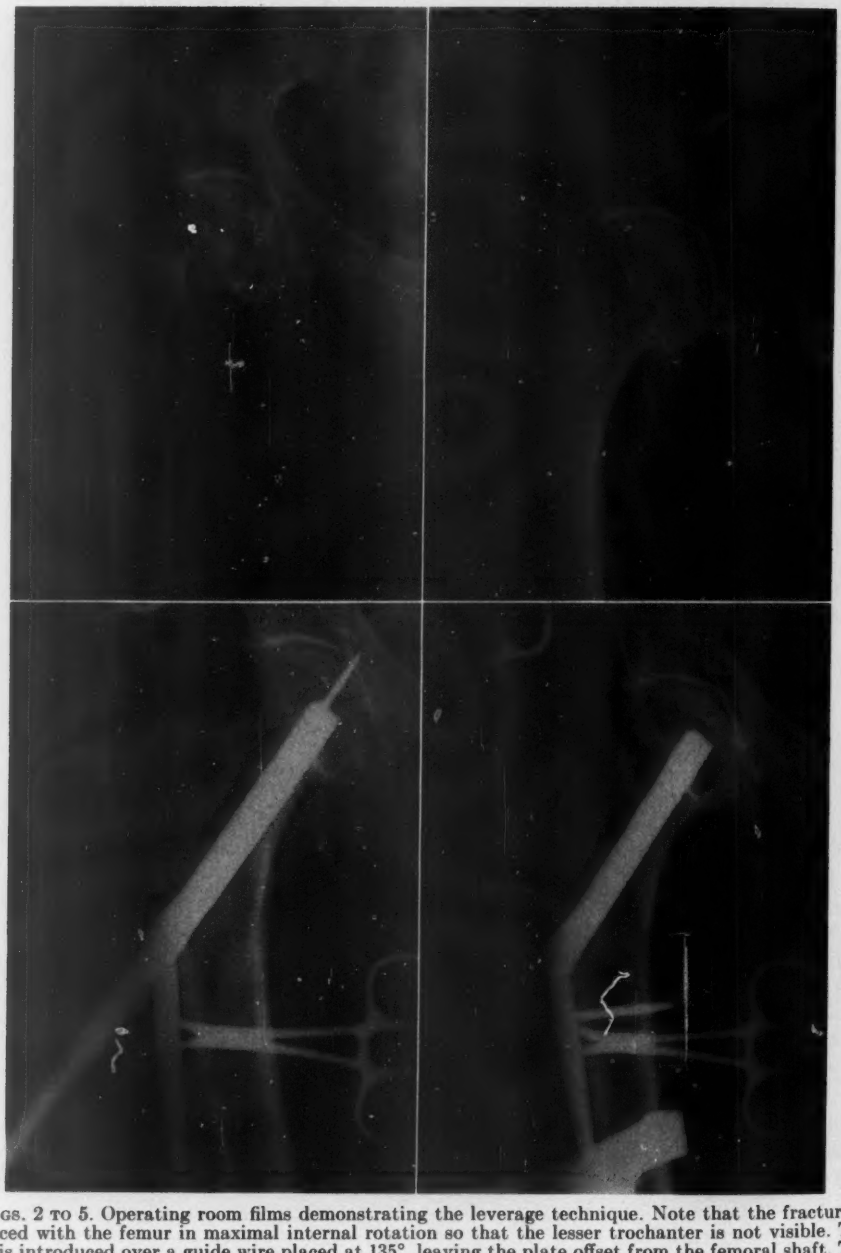


FIG. 1. The nail-plate used in this series. This nail is angled at 140° but is designed to be introduced at precisely 135° over a guide wire. The nail-plate juncture is reinforced, and only the distal 1¼ inches of the nail portion is triflanged.

For some time I have been convinced that anatomical reduction is not enough, and that the occurrence of nonunion or cutting out of the nail in intracapsular types and the occurrence of occasional varus deformity in intertrochanteric types are such unfortunate sequelae occurring



FIGS. 2 TO 5. Operating room films demonstrating the leverage technique. Note that the fracture is reduced with the femur in maximal internal rotation so that the lesser trochanter is not visible. The nail is introduced over a guide wire placed at 135°, leaving the plate offset from the femoral shaft. The plate is then impacted down to the femur, shifting the fracture into a stable impacted "abduction" position. Note in particular that the tip of the nail is slightly beyond the midpoint of the head low in the neck. Also, the lower edge of the head fragment is flush with the inferior cervical cortex.

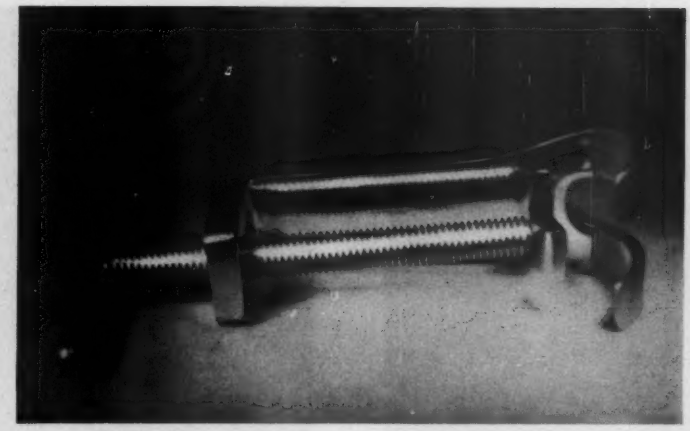


FIG. 6. This clamp is capable of compressing the nail shaft down to the femur under considerable pressure.

FIG. 7. The prosthesis as currently used, in place over the slotted nail-plate

even in apparently well nailed fractures that "something more" is needed. This added something is apparently a conversion of the fracture to stable "abduction" position in the case of intracapsular fractures, and a more positive locking and impaction in the intertrochanteric types.

TECHNIQUE

This writer, before the development of the technique to be described, used a nail-plate of the Jewett type,[3] which was felt to represent the best available device combining shaft fixation and strength. The nail* now used (fig. 1) is angled at 140° and triflanged only in the distal 1¼ inch of the nail. A small buttress is present at the nail-plate juncture, and the plate is tapered for maximal strength. This nail is introduced at precisely 135° after anatomical reduction of the fracture and use of the Jewett guide for precise placement of the guide wire low in the neck. A nail of the proper length (where the tip will lie just a fraction beyond the midpoint of the head) is driven in at 135° with a light mallet, which leaves the plate offset from the shaft of the femur 5° (figs. 2–4). Finally the plate is compressed down to the femoral shaft (fig. 5) with a special clamp (fig. 6). Such a clamp is necessary since we have found that attempts to pull the plate down to the femur are fruitless with a screw, and we had one occasion

* The hip nail, a modified nail for use with a prosthesis, and the hip prosthesis noted were developed in conjunction with the author by the Richards Manufacturing Company, Memphis, Tennessee.

where a Lowman clamp bent during the compression. The fracture is thus levered into the stable position advocated here. In intertrochanteric fractures this procedure is followed also, since the positively applied leverage through a 5° arc closes, compresses and impacts the fracture line. Technically this procedure has proved to be quite as uneventful as conventional

FIG. 8. This case is doing well, but the collar and prosthesis "overhang" the inferior cervical cortex, a point we consider undesirable.

FIG. 9. Note that the inferior edge of the prosthetic head lies on a buttress of dense reactive bone. This 88-year-old woman uses a walker for balance but has no pain and is bearing full weight.

FIG. 10. Prosthesis and collar lie within the cervical canal and a fibular graft has been driven over the spur for added stability. The slots in the plate of the special nail allow minor adjustments in a vertical plane during application of the prosthesis and later minimize shearing stresses on the screws.

TABLE 1

Case	Sex	Age	Type Fracture	Mechanical or Surgical Complications
		yr.		
1. M.	F	85	Subcapital	None
2. McP.	F	85	Subcapital	None
3. R.	F	89	Intertrochanteric	None
4. K.	F	81	Comminuted intertrochanteric	None
5. A.	F	99	Comminuted intertrochanteric	None
6. H.	F	74	Subcapital	None
7. R.	F	74	Intertrochanteric	None
8. Rem.	F	68	Subcapital	None
9. Eig.	F	78	Comminuted intertrochanteric	None
10. Br.	M	83	Grade III intertrochanteric	Inward migration of nail
11. Van N.	M	65	Pertrochanteric	None
12. E.	M	65	Comminuted intertrochanteric	None
13. S.	F	82	Transcervical	None
14. P.	F	85	Subcapital	None
15. Pitt.	F	65	Transcervical	None

FIG. 11

FIG. 13. See legends for figures 11 and 12

FIG. 12

FIGS. 11 AND 12. In this one case there was inward migration of the nail; despite this, there is no varus tendency. With the greater trochanter separated no impaction as such could be achieved, and a Bartel's osteoclasis followed by nail-plate fixation should have prevented the migration.

nailing, and with adequate x-ray control there should be no difficulties with its use. Routinely during surgery all patients have been administered 500 cc. of whole blood, 500 mg. of Matromycin intravenously in 500 cc. of normal saline, and before closure 7 gm. of Furacin powder have been freely dusted along the femoral shaft and the plate. There have been no postoperative infections and no reactions to these pharmaceutic products either in the particular cases reported here or in many other bone and joint procedures including arthrotomy of the knee where the powder has been used intra-articularly.

Three cases of a series studied before the utilization of this technique required prosthetic replacement of the femoral head; since the institution of this consecutive series none has required reoperation of any sort. In the 3 cases noted from the previous series the prosthesis (fig. 7) was especially designed with a view of emphasizing the importance of the "abducted" position. Particularly, placement of the prosthetic femoral head in such fashion that its lower edge lies *within* the lower cervical cortex on a buttress of firm bone is emphasized. We do not hesitate to trim the femoral neck somewhat to insert the prosthesis. The important thing is to rest the prosthetic head within the neck area

without overhang, as was not the situation in the first of these cases (fig. 8). This particular case is currently doing very well and is walking without pain or support, but it is obvious that the mechanical stress on plate and screws would be greater than that in the other 2 cases (figs. 9 and 10).

The prosthesis itself has been modified as is noted by illustration so that now a cortico-cancellous graft may be driven between the stem and the steel spur to allow a more positive mechanical weld and less stress on the plate and screws. Also, the modified nail-plate used in conjunction with the prosthesis is now slotted to allow for the slight motion which will occur, and heavy $\frac{3}{16}$-inch screws have been developed to fit the plate. I believe that an absolute intimate weld of steel to living tissue is impossible, but if stresses are appreciated and met in such fashion, the necessity for replacement will be

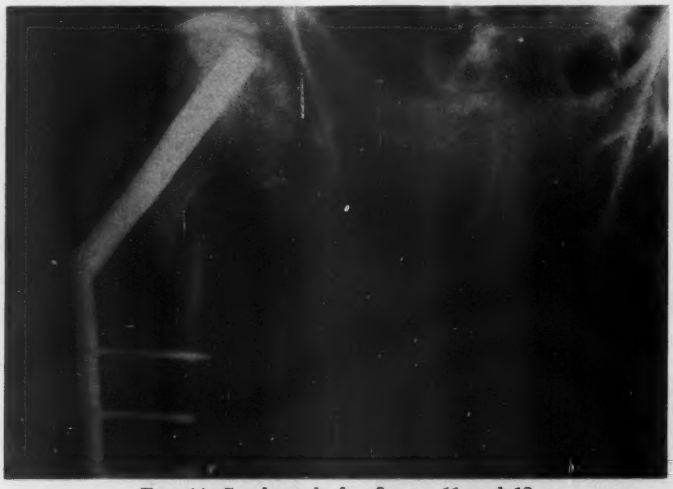


FIG. 14. See legends for figures 11 and 12

FIG. 15

FIGS. 15 AND 16. A badly comminuted intertrochanteric fracture (Case 12) with later solid union

FIG. 16

FIG. 17 FIG. 18

FIGS. 17 AND 18. A displaced high transcervical type (Case 15) fixed in "abduction". Note again that the lower edge of the neck is flush.

FIG. 19

FIGS. 19 AND 20. Comminuted intertrochanteric fracture (case 4) with later solid union and no varus tendency.

kept at a minimum. None of these prosethetic replacement cases has developed complications to date, but it is too early to evaluate their ultimate result. In any event, if replacement of any part became necessary in the future, we feel that the replacement of the modified nail-plate may be done with minimal trauma, and that the procedure should be simple enough to justify its utilization.

The 15 consecutive cases (table 1) presented in this preliminary series represent in this writer's opinion a thus far successful positive fixation of all hip fracture types with an age range from 65 to 99 years, with the use of the technique of leverage into abduction and positive impaction. In one case only was there any untoward event, and this was the occurrence of a spontaneous Bartel's osteoclasis with inward migration of the nail. This migration (figs. 11 to 14) was due to a complete separation of the greater trochanter (Class III intertrochanteric), and it is probable that this osteoclasis should have been done deliberately at the time of surgery with insertion of a shorter nail. It is interesting to note that despite the inward migration of the nail no varus deformity whatsoever has occurred. I believe that when inward migration does occur it is because of inadequate locking and impaction

FIG. 20

of the fracture at the time of surgery, and not due to "absorption at the fracture site" or "osteoporotic changes", which explanations, although convenient, do not explain that in fact a mechan-

ical failure has occurred. We agree, with McElvenny, that the well fixed hip fracture "locked in position, bone to bone" precludes appreciable migration of the nail. Several representative pre- and postoperative results of this series are noted (figs. 15 to 20).

SUMMARY

1. It is felt that the recent emphasis on routine over-reduction of fractures of the hip into an abducted or valgus position is of worthwhile note.

2. A modified nail-plate of considerable strength is presented, together with its application in achieving the over-reduced position by leverage.

3. The favorable results of this preliminary series confirm thus far the opinions of other writers who have emphasized the principle of over-reduction.

4. A modified nail and prosthesis are mentioned, and when used are placed ideally with the prosthetic head within the femoral neck and are rested on a buttress of cortical bone, coupled with a corticocancellous graft above the prosthetic stem.

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ADDENDUM

This series now consists of 26 cases, in which there has been one mechanical failure technically (case 10) and one patient failure where the 86-year-old patient began weight bearing at one month and has continued this practice intermittently since. In this case the femoral head is still viable, and union is apparently present, but the nail tip has migrated to the acetabulum.

THE USE OF UREA IN INTRACRANIAL SURGERY*

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The use of urea as a dehydrating agent was first suggested by Fremont-Smith and Forbes[1] in 1927. However, this suggestion laid dormant and unutilized until the excellent work of Javid[2] which began in 1956. During the past year there has been increasing interest in the use of intravenous urea as a dehydrating agent in intracranial surgery. It is now, we feel, an accepted agent for combating intracranial tension.

Through the generosity and cooperation of the Travenol Laboratory, a supply of lyophilized urea became available to us in June of 1958. To date we have used urea in 55 patients.

METHODS AND MATERIALS

The solution is supplied in 90-gm. units of 30 per cent urea in invert sugar. The urea crystals are contained in a sterile vacuum bottle. The invert sugar is added from a separate sterile container just before administration.

The dosage ranged from 1 to 1.5 gm. of urea per kg. of body weight. All patients weighing 60 kg. or over received the standard packaged dose of 90 gm. Patients weighing less than 60 kg. received 1.5 gm. per kg. of body weight.

The rate of administration ranged from 40 to 60 drops per minute. In some of the patients, the drug was injected by syringe over a period of 5 to 10 minutes. Rapid injection is well tolerated. In general, the full dosage should be timed so that all, or almost all, of the urea has been injected at the time of opening the dura.

Preoperative phenolsulfonphthalein studies were done in 22 cases; blood sugar, blood urea nitrogen, carbon dioxide, sodium, potassium and chloride levels were obtained before administration, immediately postoperatively, 12, 24 and 48 hours postoperatively in the majority of cases. Urinary output was collected with the use of an indwelling catheter during surgery and the quantity recorded.

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CASE REPORT

Fifty-five patients were studied up to the time of this report (table 1). In 48 of these the cerebral hemisphere, and in 5 the cerebellar hemisphere, was observed directly during craniotomy. In 2 cases the cerebrospinal fluid pressure was measured continuously for 8 and 10 hours respectively after administration of urea.

Included in this series were 10 cases of glioblastoma multiforme, 15 cases of intracranial aneurysm, 4 pituitary tumors, 5 meningiomas, 4 cases of acute craniocerebral trauma, 4 astrocytomas, 2 cases of metastatic carcinoma to the cerebral hemisphere, and 1 case each of frontal lobe meningeal sarcoma, frontal lobe brain abscess, organized intracerebral hematoma, lead encephalopathy, cerebellopontine angle chronic epidural hematoma and cerebellopontine angle tumor. Three posterior fossa explorations were performed in the absence of mass lesions. One of these was an 8th nerve section for Ménière's disease, one a 5th and 9th nerve section for pain, and one a negative exploration of the angle for suspected tumor. In addition, there was one transtentorial exploration of the cerebellar hemisphere from beneath the temporal lobe for visualization of the cerebellum, pontine peduncle and upper pons.

Clinical Results

The results were graded in the following manner: *Excellent*, if the brain was markedly depressed and retracted away from the level of the bone on opening the dura; *good*, if the brain was essentially normal tension or only slightly depressed, despite the presence of a large mass lesion, and obvious evidence of marked increased intracranial pressure preoperatively, and became markedly depressed after tumor removal; *moderately good*, if the brain was only slightly more swollen than normal on opening the dura and continued to slowly shrink in size during the procedure; *fair*, if the brain was only minimally tight throughout the procedure despite the clinical evidence of marked increased intracranial pressure preoperatively; *poor* if there was essentially no response, or if the brain remained markedly swollen and tight despite urea.

Of the 53 patients observed at operation, 29 were graded excellent, 12 good, 2 moderately good, 3 fair and 7 were graded as poor results. A total of

41 of the 53 cases were rated as good or excellent responses (see table 1).

This can be broken down further: In 10 cases of glioblastoma multiforme 3 results were excellent, 5 good and 2 poor. In 15 aneurysm cases 10 were excellent, 2 good, 1 moderately good and only 2 results were poor. The 2 poor cases were acutely ruptured aneurysms with the patients in decerebrate rigidity from tentorial herniation and large intracerebral hematomas present. Four pituitary tumor cases were graded as excellent results. Of 5 meningioma cases, 3 were rated as good, 1 excellent and 1 moderately good; all were large meningiomas with marked increased intracranial pressure. The meningeal sarcoma result was good. In 4 astrocytoma cases 1 was rated as excellent, 1 good and 2 fair; 1 case of organizing intracerebral hematoma had an excellent response; 1 case of brain abscess was rated excellent at the time of resection; 1 case of lead encephalopathy, with decerebrate rigidity and a dilated, fixed pupil, was graded excellent at the time of opening the dura.

The 5 cases in which the posterior fossa was explored all had excellent results with urea. The cerebellar hemisphere was markedly shrunken and depressed from the bone on opening the dura; 2 of these had mass lesions; 1 was a case of an epidural hematoma in the cerebellopontine angle and the other was an 8th nerve neurinoma which was unusually large and yet did not require resection of any cerebellum for exposure. Three additional angle explorations were done in the absence of a mass lesion. One 8th nerve section for Ménière's syndrome, one 5th and 9th nerve section for carcinoma pain and one negative exploration for a cerebellopontine angle syndrome were done. In all cases the cerebellar hemisphere retracted readily and showed no tendency to re-expand for several minutes after the removal of the retracting force. There was 1 transtentorial exploration of the posterior fossa through the subtemporal root which showed an excellent response to urea. In 2 cases of metastatic carcinoma, 1 showed an excellent response and 2, with preoperative coma, showed only a minimal response.

Of the 4 cases of acute craniocerebral trauma, 3 results were poor and 1 excellent. The 3 poor cases were acute cerebral contusion and edema problems. Tentorial decompressions were done, and, because of marked brain swelling, urea was given. In 2 cases, cortical resection was necessary to close the galea.

The one good result in trauma was a 3-year-old child in whom the urea was given rapidly by syringe and lumbar puncture pressure measured continuously. The child improved with the urea and then regressed again after 8 hours. He was suspected of having cerebral contusion and edema but at operation had large subdural hematomas bilaterally and very little edema.

TABLE 1

Results of urea administration in 55 craniotomies plus 2 continuous spinal pressure record

Procedure	No. of Cases	Excellent	Good	Moderately Good	Fair	Poor
Glioblastoma	10	3	5			2
Intracranial aneurysm	15	10	2	1		2
Pituitary tumor	4	4				
Meningioma	5	1	3	1		
Trauma	4	1*				3
Astrocytoma	4	1	1		2	
Meningeal sarcoma	1		1			
Brain abscess	1	1				
Metastatic carcinoma	2	1			1	
Transtentorial cerebellar exploration	1	1				
Lead encephalopathy	1	1				
Intracerebral hematoma	1	1				
Cerebellopontine angle, mass lesion	2	2				
Cerebellopontine angle exploration without mass	3	3				
Torula meningitis	1	1†				
Totals	55	31	12	2	3	7

* A 3-year-old child given urea and spinal fluid pressure followed for 8 hours, rebound after 6½ hours.

† A 51-year-old man with torula meningitis. Fluid pressure followed 12 hours, rebound after 5 hours, lasted additional 5 hours until discontinued.

A second dose of urea was given postoperatively to 4 patients and 1 patient was given an initial course of urea postoperatively when he showed signs of increasing cerebral edema. In none of these was there any sign of improvement in the clinical picture or tenseness of the craniotomy flap after the administration of the drug.

Urinary output ranged from 200 to 2150 cc. during the operative procedure with an average output of 877 cc.

Two cases were followed by continuous lumbar cerebrospinal fluid pressure measurement after administration of urea in order to determine the presence or absence of any rebound phenomena. One of these was a 3-year-old child with craniocerebral trauma. As noted above, a diagnosis of cerebral contusion and edema was made, and urea was administered. The spinal fluid pressure fell from 170 mm. of water to 0 over a period of 34 minutes, remained at 0 for 81 minutes and did not

reach the preurea level until an additional 4 hours and 20 minutes had passed. After this it was noted that the pressure rose above the opening pressure to 200 mm. of water. The second case was one of torula meningitis. The cerebrospinal fluid pressure fell from 136 to 0 in 95 minutes, remained at 0 for 30 minutes and slowly rose to 136 over another 140 minutes. The pressure was obtained for an additional 2 hours and 50 minutes after this. It rose slowly to 440 mm. over the first 2 hours and 15 minutes and remained there until measurement was discontinued after another 35 minutes.

Laboratory Results

There was no appreciable change in the carbon dioxide, sodium, potassium, or chloride levels in the blood after this procedure. Preoperative blood urea nitrogen levels ranged from 3 to 51 mg. per cent with an average of 13. Only one was above 24. Immediately postoperative, blood urea nitrogen ranged from 36 to 172. Seven were above 100 and seven below 60. Twelve hours after surgery the blood urea nitrogen ranged from 13 to 150. Of these, only three were above 60. Preoperative phenolsulfonphthalein and urine analysis indicated normal urinary function in all cases tested.

Complications

No untoward effects resulted from the use of urea. In one case[3] the anterior chamber of the eye was noted to be collapsed and caved in immediately postoperative, but this returned to normal within 12 hours. There were no visual difficulties in this patient on awakening from surgery. In all cases the eyes were noted to be soft to palpation.

DISCUSSION

Urea, as other osmotic dehydrating agents used to counteract brain edema, acts by maintaining an osmotic pressure difference between the blood and cerebral extracellular fluid spaces. All previously used agents for combating cerebral edema have been found inadequate clinically. Javid has shown that urea enters the cerebrospinal fluid at an extremely slow rate. One can assume that it does not reach the cerebral extracellular space very much faster than it reaches the cerebrospinal fluid space. The main advantage of urea is that it is excreted rapidly and does not enter the brain fast enough to produce extensive or prolonged rebound edema as do the other nontoxic brain dehydrating agents. This, combined with the freedom from toxicity of the urea, makes it an excellent agent.

In 2 cases, in which the spinal fluid pressure was measured continuously, the pressure did not return to preurea levels for 8 hours in one and 4½ hours in the other. Both of these cases showed rebound increase in cerebrospinal fluid pressure. However, neither case was entirely satisfactory for this study. In one the pressure increase was only 30 mm. of water. This patient proved to have bilateral subdural hematomas and the minimal increased pressure may have been due to the mass expanding. The second case was one of torula meningitis in whom wide variations in cerebrospinal fluid pressure had been noted previously and the rise of 300 mm. of water pressure may have been a manifestation of the normal pressure fluctuations present with his disease. Further studies concerning rebound phenomenon are in order before any conclusions can be drawn.

In our series the blood urea nitrogen values returned almost to normal within 12 hours postoperative, and this was accompanied by a marked diuresis, indicating that the fall in urea levels was due primarily to urinary excretion.

SUMMARY

We have found the administration of intravenous urea to be of invaluable aid in exploration of the base of the brain as in aneurysm and pituitary surgery. The shrinkage of normal brain that one sees in these patients makes retraction and exposure very much simpler and less traumatic. Of the twenty-one exposures done in this area, sixteen were graded as excellent responses, three as good, and only two as poor.

In addition, urea appears to be useful in reducing the size of the brain and eliminating brain edema in cases of hemisphere mass lesions. In this group the tumor is more readily delineated from surrounding brain, the surgical task made easier and the danger of tentorial herniation from increasing edema during exposure of the brain is reduced.

The five cases of posterior fossa exploration in which urea was used proved the effectiveness of this agent in this region. The single case of angle tumor suggests that the large cerebellar pontine angle lesions, formerly requiring cerebellar resection, may now be done with greater ease and without resection of normal tissue. It may be that cerebellar shrinkage will replace cerebellar resection in the extirpation of cerebellopontine angle tumors in the future. One must be careful

in using the sitting position for posterior fossa explorations with urea since the cerebral shrinkage in this position may result in tearing of bridging dural vessels and result in subdural hematoma. It is, therefore, advisable not to use this agent in the sitting position.

Our experience in the use of urea in postoperative and post-traumatic massive cerebral edema has been limited to nine patients. In all of these but one the results have been poor. This series is too small to be able to draw definitive conclusions. However, it is suggested that brain trauma, surgical or nonsurgical, may alter the blood brain barrier, allowing urea to enter the cerebral extracellular spaces and neutralize the osmotic effects. Further studies will be required in this direction.

It is our conviction that intravenous urea is no longer an experimental drug, and its use marks an important technical advance in intracranial surgery.

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CHOLELITHIC INTESTINAL OBSTRUCTION: REPORT OF FOUR CASES

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One of the most uncommon causes of mechanical obstruction of the gastrointestinal tract, is the impaction of a gallstone. Intestinal ileus of this kind is a rare condition, responsible for less than 2 per cent of obstructions of the bowel. It occurs as a complication of chronic cholelithiasis. In the majority of cases the stone erodes, by pressure necrosis, through the wall of the gall bladder or the common bile duct, into the duodenum, stomach or hepatic flexure of the colon, thus creating an internal biliary fistula between the biliary and the alimentary canal. The stone carried by the peristaltic waves of the intestine proceeds further until it becomes impacted, usually at the region of the terminal ileum and ileocecal valve.

CLINICAL PICTURE AND RADIOLOGIC FINDINGS

The symptoms of gallstone ileus are those of a mechanical obstruction of the small intestine and occasionally of the colon. The patient usually is an elderly obese woman, with or without a previous history of biliary disease. Obstructive symptoms—abdominal colicky pain, constipation, distention, nausea and vomiting—are usually intermittent as the stone passes along to a lower level, where it becomes impacted and ultimately causes complete obstruction. Fecal vomitus, dehydration and electrolyte imbalance gradually become part of the clinical picture.

The preoperative diagnosis of a cholelithic intestinal obstruction is almost impossible without the contribution of roentgenologic studies. A flat x-ray film of the abdomen will show dilated loops of small bowel, probably air in the biliary tree and occasionally a gallstone shadow outside the right upper quadrant. A barium meal or a barium enema will demonstrate the presence of the internal cholecystoenteric fistula by outlining the biliary tree. Such demonstration was obtained in 3 of our cases (figs. 1 to 4).

Occasionally there will be also demonstrated in the small or large bowel a filling defect which is due to the presence of the impacted, semi-opaque gallstone. Careful evaluation of the history and clinical picture, along with some or all of the above described radiologic findings, will lead, in very many instances, to an early correct diagnosis, for the great benefit of the patient.

TREATMENT

The treatment of this complication is surgical. Even in patients in whom the preoperative diagnosis has not been obtained, an exploratory laparotomy for mechanical obstruction is mandatory. Reasonable preparation, hydration and electrolyte balance, will be necessary.

Thorough exploration of the entire length of the bowel should be carried out to assure that multiple calculi have not been overlooked. The obstructing stone or stones will be located and usually milked out through a longitudinal enterotomy, made proximally to the obstructed site, where the bowel wall is more healthy. This incision is closed transversely to prevent stenosis of the intestinal lumen. Pressure gangrene or perforation are fortunately seldom encountered. This requires resection of the involved intestinal segment.

Most surgeons agree that at the time of emergency surgery for cholelithic intestinal obstruction, cholecystectomy or repair of the internal fistula should not be attempted. The elderly age of most of these patients, combined with a usually delayed diagnosis, probably accounts for the reported high mortality rate (30 to 50 per cent).

CASE REPORTS

Case 1. (E-2219). Mrs. J. A., a 67-year-old white woman, was admitted to Mercy Hospital, complaining of persistent constipation for the previous 6 days, accompanied by suprapubic intermittent colicky pain. On physical examination the abdomen was distended and slightly tender over the suprapubic and right lower quadrant regions.

Sigmoidoscopic examination revealed an obstruction of the sigmoid colon at 18 cm. A barium enema showed a persistent filling defect in the midsigmoid, measuring about 4 by 3 cm. and par-

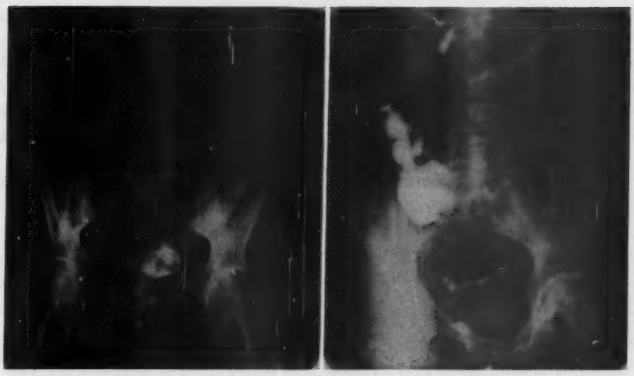

FIG. 1 *Left*, obstructing stone in the midsigmoid. *Right*, barium enema demonstrates cholecystocolic fistula, outlining the biliary tree.

FIG. 2. Barium meal demonstrates cholecystoduodenal fistula, with perfect outlining of the biliary ducts.

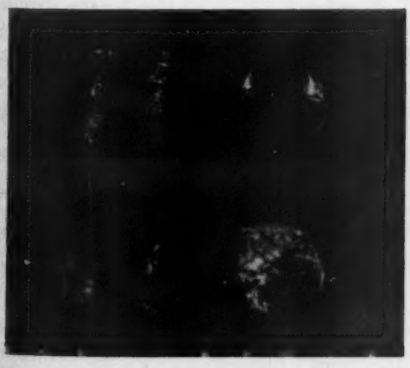

FIG. 3. Gallstones removed from the terminal ileum.

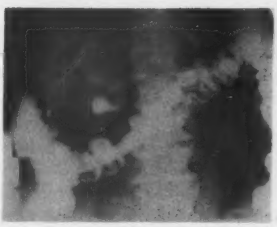

FIG. 4. Barium meal demonstrating cholecystoduodenal fistula; barium outlines the entire biliary tree.

tially obstructing the lumen (fig. 1, *left*). The barium enema also demonstrated the presence of an internal fistula between the gall bladder and the hepatic flexure of the colon (cholecystocolic fistula, fig. 1, *right*). The biliary tree was perfectly outlined by the radiopaque medium, and a diagnosis of a cholelithic intestinal obstruction was made.

After the barium enema, the patient expelled a large gallstone and the obstruction was quickly relieved. Laparotomy was performed, a week later, and cholecystectomy with repair of the internal fistula was carried out.

The patient made an uneventful convalescence and was dismissed from the hospital on the 9th postoperative day.

Case 2. (U-3184). J. K., a 45-year-old white woman, was admitted to Mercy Hospital with a diagnosis of partial intestinal obstruction. The history revealed an episode of jaundice 15 years ago. The physical examination showed an obese woman with marked abdominal distention and increased peristalsis; there was diffuse abdominal tenderness, more pronounced over the right upper quadrant.

A flat x-ray film of the abdomen revealed small bowel obstruction with multiple loops of dilated intestine. A small barium meal was administered. It demonstrated a cholecystoduodenal fistula. The gall bladder and the biliary ducts were clearly outlined by the barium. A diagnosis of gallstone ileus was made.

On abdominal exploration, the terminal ileum was found to be obstructed by two cylindric, faceted calculi. Enterotomy was performed proximally to the obstructed site and the stones milked out and removed. The longitudinal ileotomy was closed transversely.

Cholecystectomy or repair of the cholecystoenteric fistula, was not attempted at this time.

The patient recovered uneventfully and left the hospital on the 10th postoperative day.

Case 3. (S-2016). Mrs. M. H., a 74-year-old white woman, was admitted to Mercy Hospital through the Outpatient Clinic, with a history of constipation for the last 4 days and intermittent colicky pain across the upper abdomen, nausea and vomiting. On physical examination the abdomen was moderately distended and tender over the right upper quadrant. No history of previous biliary disease was obtained. Flat x-ray plate of the abdomen showed a typical small bowel obstruction. Barium enema demonstrated diverticulae of the discending colon. Decompression of the small bowel was accomplished by a Miller Abbott tube.

Surgical exploration of the abdomen revealed 4 stones in the terminal ileum obviously causing obstruction near the region of the ileocecal valve. Enterotomy was performed proximally to the obstruction and 4 gallstones (fig. 2) were milked through the incision. The patient made an uncomplicated postoperative course and uneventful recovery and was dismissed on the 7th postoperative day in good condition.

Case 4. (W-291). Mrs. M. D., a 78-year-old white woman, was admitted to Mercy Hospital. She complained of right upper abdominal pain, radiating to the right shoulder, nausea, vomiting and constipation. On physical examination, the abdomen was slightly distended, with moderately increased peristalsis.

A barium enema demonstrated a colon normal in caliber and without defects. A barium meal showed the stomach to be normal with a fistula between the duodenal bulb and the gall bladder. An oval shadow of decreased density, the size of an egg, apparently a gallstone, was demonstrated in the region of the terminal ileum. A diagnosis of cholelithic intestinal obstruction was made. On surgical exploration, 2 days later, a large gallstone 4 by 3 by 2.5 cm. was removed through a longitudinal enterotomy (terminal ileum).

The patient seemed to be recovering satisfactorily, when, on the 4th postoperative day, she developed acute shortness of breath, cyanosis, precordial (substernal) pain and expired. An autopsy was not performed.

SUMMARY

The pathogenesis, clinical picture, radiologic findings and treatment of cholelithic intestinal obstruction have been discussed. Four cases of gallstone ileus have been presented.

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XIPHOID-INTERPOSITION: A TECHNICAL MODIFICATION FOR THE REPAIR OF PECTUS EXCAVATUM*

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The treatment of pectus excavatum is a subject of much dispute. Most thoracic surgeons agree that this abnormality should be corrected in advanced cases; however, there is much discussion as to what is an "advanced case"; what is the optional age for repair, and what surgical method offers the best results.

In the Department of Thoracic Surgery and Cardio-Pulmonary Research Laboratory, Charlotte Memorial Hospital, we have operated on 127 patients with this deformity in the past 14 years. There were no deaths and by and large the functional improvement was satisfactory. The cosmetic results, however, were such that we felt it necessary to improve our technique; thus, we developed a method of interpositioning the xiphoid process. The over-all details of our experiences are to be published separately.[13] We wish to discuss in this communication only a new modification of the operative technique, *i.e.*, the application of the xiphoid process as an internal, living support. This maneuver is easily effected and has improved our cosmetic results remarkably.

Ludwig Meyer,[8] in 1911, reported the first surgical intervention of a pectus excavatum problem. Since then, more than 20 different operative procedures have been devised for the correction of this deformity. Principally, the authors agree in recommending a more or less extensive osteotomy of the sternum and/or resection of the costicartilages. All of these techniques can be cataloged into 3 groups: (1) operations which do not use special support or fixation,[3, 4, 6, 8, 11, 14-16] (2) methods where (temporary) external support, usually traction or splints, are applied,[2, 7, 9, 10, 12] and (3) procedures with internal support or fixation (homologous rib).[1, 5]

The method we use is essentially a modification of the procedure described by Ravitch.[11] Endotracheal anesthesia is used, and a longitudinal incision is made from the manubrium sterni to the lower end of the xiphoid process. The pectoralis muscle is incised along its attachment to the sternum on either side, then stripped and retracted to the costicartilagenous junction. Thereupon, carefully avoiding the opening of either pleural cavity, we removed all the deformed costicartilages subperichondreally. The xiphoid process is separated from the sternum at its articular attachment. In cases where this process is rudimentary or the sternum is extremely elongated, the line of separation is made ½ inch above the sternoxiphoid articulation. This is followed by a transverse cuneiform osteotomy of the sternum, at the beginning of the downward curve. The site of this osteotomy is usually the level of the 2nd to 3rd costicartilage. Thereafter, the intercostal muscular attachment with the perichondrium is severed from the lower two-thirds of the sternum on either side. The posterior surface of the sternum is freed of its mediastinal attachment. Afterwards the sternal bone is bent anteriorly. Thus the "excavatum" disappears into a slightly overcorrected position.

By cutting the anterior rectal fascia on either side of the xiphoid process, it is mobilized whereby it can be stretched up under the lower portion of the sternum. In this position the process is secured by anchoring it with stainless steel wire sutures bilaterally to the 3rd, 4th or 5th subchondral strips. In this manner the xiphoid process in this substernal position serves as an internal support.

After the "interposition" of the xiphoid process, the pectoralis muscle is reattached to the sternum on either side with interrupted sutures. The subcutaneous tissue is likewise closed, as is the skin.

This technical modification has been used in 20 patients varying in age from 2 to 29 years. The procedure was tolerated well in each in-

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stance. The functional results remained satisfactory, but it was especially gratifying to be able to state that the patients and the surgeons were pleased with the appearance of the correction.

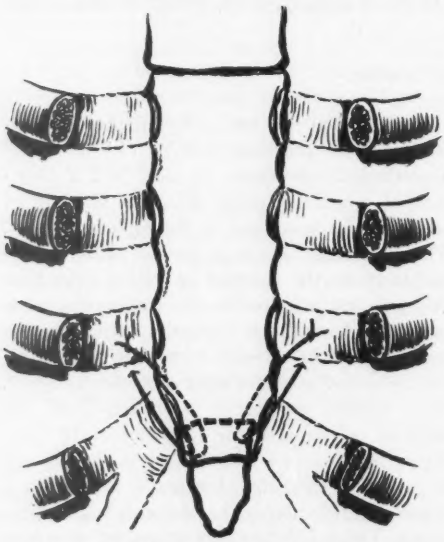

FIG. 1. Schematic representation of the procedure.

Pneumothorax, if it is recognized and handled properly, is not regarded as a serious complication. This occurred in 3 instances. The average time of hospitalization was 8 days.

The common denominator in pectus excavatum is depression of the sternal bone and adjacent costicartilages. It varies widely in its form and clinical manifestations. When the surgeon thinks the deformity should be corrected, the basic principle of the repair is the mobilization of the sternum and the resection of the costicartilages. To secure a corrected position of the sternum, many surgeons think that the procedure should entail some form of external-internal fixation.

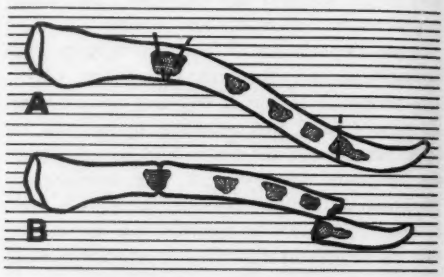

FIG. 2. Lateral view of the sternum before (*A*) and after (*B*) xiphoid-interposition.

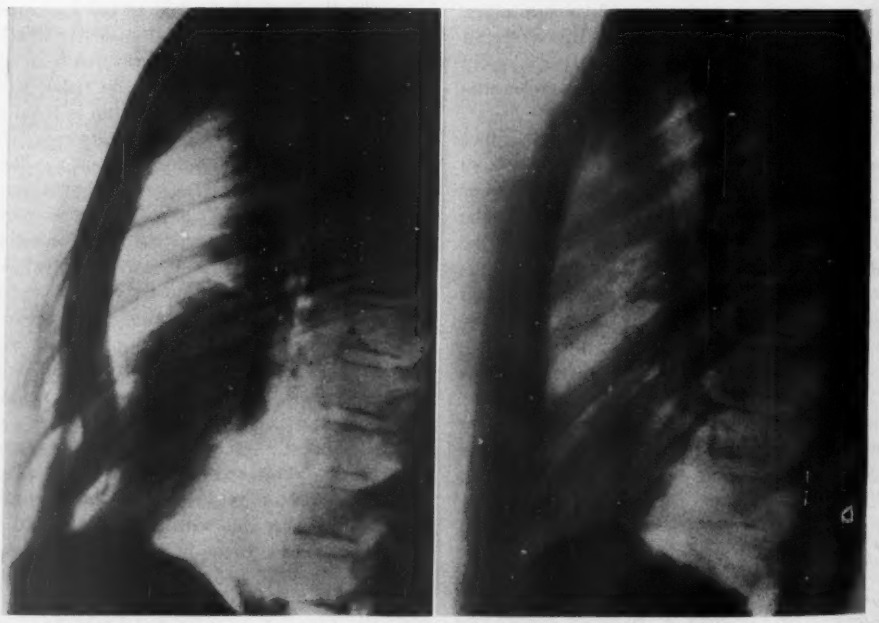

FIG. 3. S. E., 14 years old, pectus excavatum. Lateral chest x-ray films taken before (*left*) and after (*right*) surgery.

We have found that the simple and effective use of live tissue of the xiphoid process interpositioned beneath the sternum results in good physiologic function and cosmetic appearance. Furthermore, it has these advantages: (1) It does not become a source of sterile necrosis which is common with homologous rib implants; (2) it helps to obliterate the existing dead space that otherwise remains posterior to the sternum; and (3) the anchoring of the xiphoid process with its rectus muscle attachment prevents the loose, "potbelly" appearance of the abdominal wall, commonly observed in patients after repair of this deformity.

SUMMARY

The authors describe a new modification in the operative technique of pectus excavatum with the xiphoid-interposition. After resection of costal cartilages, cuneiform osteotomy and mobilization of the sternum, the sternal bone is brought in a slightly overcorrected position. This position is secured by using the severed xiphoid process as an internal, living support. The operative technique and the advantages of the procedure are described in detail.

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INADVERTENT PRIMARY RESECTION FOR THE COMPLICATIONS OF SIGMOID DIVERTICULITIS*

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The complications of sigmoid diverticulitis remain a challenge to the medical profession. A significant morbidity and mortality are influenced not only by the severity of the disease but also by the the other debilitating conditions in the older age groups.

When perforation, abscess, fistula or obstruction occurs, the surgeon's emergency care should adhere to the tried and proved principles of proximal diversion colostomy, exteriorization procedures and drainage of abscesses. Occasionally in the face of severe hemorrhage a primary resection of the diseased bowel would seem desirable when conservative management fails. If carcinoma is suspected with acute diverticulitus, a proximal colostomy and an early re-exploration after proper bowel preparation would seem advisable. If, on the other hand, perforation of a diverticulum cannot be distinguished from a perforation of a carcinoma, then the surgeon must consider an exteriorization operation or a primary resection of the diseased segment because a perforated carcinoma may not seal off or remain sealed with a diversion colostomy alone.

The purpose of this discussion is to report on 4 patients who underwent primary resection with end-to-end anastomosis in the face of perforation and abscess of the left colon. In each instance the error in judgment and management was based on the erroneous belief that the underlying pathology represented carcinoma with perforation. In 2 instances no diverticulae of the adjacent colon were evident. Because other surgeons may sometime be in a similar dilemma, the successful management of these 4 patients would seem to be worthy of review.

All were men with the ages of 40, 56, 71 and 74 years, respectively. Two patients were operated upon as night emergencies; one with a preoperative diagnosis of volvulus and the other with a preoperative diagnosis of mesenteric thrombosis. A third patient underwent exploration for a dissecting aortic aneurism and the perforated diverticulum was a surprise. The fourth patient was explored in the face of a left lower quadrant abscess because the radiologist felt he could not exclude carcinoma of the sigmoid colon concomitant with diverticulitis. This latter patient was the only one in this series who had any bowel preparation.

* Read at the Southeastern Surgical Congress, Miami Beach, Florida on March 9, 1959.

INTESTINAL RESECTION

The intestinal resection with end-to-end anastomosis was technically easy in one instance; but difficulties with edematous bowel and friable mesentery made the other 3 operations hazardous. It was particularly apparent that an adequate mesenteric dissection with the regional lymph nodes was probably not accomplished. On the other hand, such a resection was regarded as palliative because of perforation of the suspected malignancy.

A two-layer anastomosis with interrupted fine chromic catgut and cotton sutures was accomplished in each instance without any tension on the suture line. All 4 anastomoses healed without leakage.

CECOSTOMY

Each of the 4 patients had a complementary cecostomy as a necessary safety precaution. No attempt was made to exteriorize the cecum. A no. 20 French de Pezzer-type catheter was used. The tube cecostomy was accomplished with a simple purse string suture in the bowel followed by Kader sutures which were anchored to the parietal peritoneum. The tube catheter was exteriorized through a stab wound in the right lower quadrant.

Each de Pezzer catheter was secured to the skin with a fine stainless steel wire suture.

One cecostomy tube was removed on the 7th postoperative day; all were out by the 11th day. The cecostomy tubes were permitted to drain by gravity over the side of the bed to a drainage

TABLE 1

Case	Age	Preoperative Diagnosis	Pathology	Bowel Preparation	Operation	Discharged
	yr.					*day*
1	40	Volvulus	Diverticulitis, multiple peri-colic abscesses	None	Sigmoid resection, end-to-end anastomosis, tube cecostomy, Penrose drain	12th
2	56	Diverticulitis with abscess, possible carcinoma by x-ray	Suppurative diverticulitis	Sulfathalidine enemas, liquid diet	Sigmoid resection, end-to-end anastomosis, tube cecostomy, Penrose drain	8th
3	71	Mesenteric thrombosis	Perforation sigmoid colon, mechanical small bowel obstruction	None	Lysis of adhesion, surgical decompression, sigmoid resection, tube cecostomy, Penrose drain	16th
4	74	Aortic aneurism	Aortic aneurism, perforated diverticulum descending colon, cirrhosis	None	Exploration aneurism, resection left colon, cecostomy, gastrostomy, liver biopsy	14th

bottle. Catheters were flushed with saline, and ½ ounce of mineral oil was instilled daily after the 2nd postoperative day.

LEVIN TUBE

Nasogastric decompression with a Levin tube was maintained for 3 days on 3 patients. In one instance the Levin tube could not be passed, and, therefore, a gastrostomy tube was utilized. Initially, the gastrostomy tube functioned effectively by siphon drainage; later, the gastrostomy tube was used for feeding purposes. The gastrostomy tube was removed on the 12th postoperative day.

PENROSE DRAINS

A Penrose drain was exteriorized through a stab wound in the left lower quadrant and placed down in the pelvis on 3 patients. All drains were left untouched until the end of the 1st week when gradual mobilization was started. A late complication at the suture line was feared but none occurred.

INCISION AND WOUND CLOSURE

All patients were explored through a vertical incision of the midline or paramedian type. The wounds were closed with interrupted figure-of-eight stainless steel no. 32 wire. No retention sutures were placed. One superficial wound infection required simple drainage.

ANTIBIOTICS

Prophylactic antiobiotics were given during the immediate postoperative period in all 4 patients. A penicillin-streptomycin combination was used in the early cases; Chloromycetin was also favored.

DIET

Liquids by mouth were withheld until the 5th postoperative day. Pureed vegetables, cooked cereals and semisoft foods were not permitted until the 2nd week.

DISCUSSION

Staged operations would have been performed on these 4 patients if the true, benign nature of the sigmoid pathology had been known. It is felt, however, that if primary resection is inadvertently performed for the complications of sigmoid diverticulitis, then the patient should have a simultaneous transverse colostomy or a cecostomy for decompression. Conservative use of prolonged parenteral fluid therapy would seem to have influenced the successful outcome in these resections. The surgeon must resist the temptation of early feeding of residue foods during the 1st postoperative week.

SUMMARY

1. An inadvertent primary resection was performed on four patients with perforation of the sigmoid colon.

2. In each instance the resection was performed in the belief that carcinoma was present.

3. Cecostomy, Levin tube drainage, accurate anastomosis without tension and the withholding of a residue diet until the second week were believed to be the most important factors in the excellent recovery of these patients.

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INTERNAL MAMMARY LYMPH NODE BIOPSY AS A GUIDE TO POSTMASTECTOMY RADIATION THERAPY IN BREAST CARCINOMA

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Nearly a century has elapsed since Billroth, Volkmann, Kuster, Konig and others began to evaluate different operative techniques in the surgical treatment of breast carcinoma. Their efforts were concerned largely with operations to limit local recurrences of carcinoma, yet it is from the work of these surgeons that the classical radical mastectomy was derived by Halsted. He stated that Kuster was the earliest advocate of a systematic cleaning-out of the axilla and that Volkmann excised the pectoralis major muscle and with it, sometimes, the pectoralis minor. For a period of time, while Bloodgood was Halsted's resident surgeon, supraclavicular node resection was included within the scope of the operation of radical mastectomy. Later, Halsted noted that, "Doctor H. W. Cushing my house surgeon, has in three instances cleaned out the anterior mediastinum on one side for recurrent cancer. It is likely, I think, that we shall in the near future remove the mediastinal contents at some of our primary operations."[4]

Thus, Halsted was aware of lymphatic spread of carcinoma from the breast to the mediastinal and supraclavicular areas, yet he failed to include these areas in the resection in the final evolution of his operative procedure for breast carcinoma. His radical mastectomy, with removal of the pectoral muscles and dissection of the axilla for removal of lymphatic tissue, nevertheless became the unquestioned surgical approach to carcinoma of the breast. This procedure still predominates as the operation of choice although there is dissatisfaction with its extent and final accomplishment since it fails to account for total lymph node spread from the breast.

In 1947 Handley and Thackray,[5] basing their study on work done by W. Sampson Handley between 1922 and 1927, reported upon 5 patients in whom removal of lymph nodes of the internal mammary chain from the homolateral second intercostal space had been done. They found metastatic breast carcinoma in this node in 4 of the 5 patients. Handley continued this study and in 1954[6] reported upon 150 patients in whom he found the internal mammary nodes involved in one-third. When the lesion was located in the subareolar area or in the medial half of the breast, the internal mammary nodes were involved 54 per cent of the time. In 6 per cent of his patients the only spread found was to the internal mammary nodes. In 1949 Andreassen and Dahl-Iversen[1] reported on the incidence of lymphatic spread of carcinoma of the breast to the supraclavicular lymph nodes. In 1954 Andreassen and associates[2] reported a follow-up on this earlier work. In 100 patients the over-all spread was as follows: 41 per cent axillary node metastases, 17 per cent internal mammary node metastases and 3 per cent supraclavicular node metastases. These figures created new interest in the internal mammary nodal chain as a frequent site of secondary carcinoma from the breast.

Since the late 1940's there had developed several different viewpoints in the surgical treatment of carcinoma of the breast. One group, led by Margottini,[8] Urban[15, 16] and Wangensteen,[18] has extended the operation of radical mastectomy. Urban and Margottini included, in addition to the usual radical mastectomy, an *en bloc* resection of the costal cartilages, the internal mammary vessels, and the lymphatic chains in the parasternal area. Wagensteen, in a selected series of 64 patients, split the sternum and dissected out the internal mammary and supraclavicular lymphatic tissue; in this selected series "with more advanced disease", 57.8 per cent[18] had cancer that would have been beyond the limits of the conventional radical mastectomy. The operative mortality among Wangensteen's patients was 12.5 per cent. McDonald and associates,[9] on the other hand, have proposed limiting the operation of radical mastectomy to those patients in whom biopsy of the internal mammary nodes and supraclavicular nodes, as

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a means of establishing their criteria for radical mastectomy, reveals no metastatic carcinoma. Thirty-six per cent of their patients had positive internal mammary nodes when this technique was used. Sandy[12] also applied internal mammary node biopsy for the selection of patients for radical mastectomy.

Quite in contrast to these surgeons who are seeking increased survival and cure rates by extending the scope of the conventional radical mastectomy McWhirter[10] has taken an approach of conservatism. The basic tenet of his work presumes, like that of most surgeons, that the classical radical mastectomy fails because it neglects the lymphatic extension to the internal mammary chain and the supraclavicular nodes. He proposes simple mastectomy for all operable breast carcinoma and rejects for operation only those patients who have demonstrated distant metastases. Operation is followed by radiation therapy consisting of a tumor dose, 3750 r given in a period of 3 weeks, to the chest wall and to the whole length of the axillary chain and the supraclavicular and internal mammary nodes.

It is generally accepted that after the usual methods of treatment, patients with lesions in the medial quadrants of the breast have a survival rate at the end of 5 years much less than those with lesions elsewhere in the breast. Statistics published by the British Institute of Radiology upon 821 patients from the Royal Cancer Hospital of London[13] give the absolute 5-year survival for patients with lesions of the inner quadrants as 38.4 per cent. This figure correlates well with the incidence of metastasis of carcinoma from the breast to the internal mammary chain. When the lesion was in the medial half of the breast, Handley and Thackray[6] reported positive internal mammary nodes in 54 per cent of 150 patients. Sandy[12] reported 68 per cent of the patients had metastases in the internal mammary nodes. This over-all mortality for patients with medial-half lesions treated by the conventional radical operation approximates the rate of metastases to the internal nodes from lesions within the medial half of the breast. Of special interest in McWhirter's study[10] are his figures for carcinoma in the medial half of the breast. He reports his highest survival rate in patients with lesions of the medial half of the breast; 58 per cent of 248 patients survived 5 years. He states, "The five year survival rate is higher in patients where the tumor was in the inner half of the breast. While the difference is not statistically significant the findings suggest that radiotherapy can destroy malignant diseases in the internal mammary glands."

That the internal mammary lymphatic chain is important in the spread of mammary cancer seems well established. Using material obtained from *en bloc* dissection of the internal mammary chain, Urban[16] determined that lymphatic tissue is present in decreasing percentage from the 1st to the 5th space as follows: 91 per cent, 89 per cent, 75 per cent, 53 per cent and 13 per cent. This is in agreement with Stibb's[14] work as reported by McDonald.[9] Although we know of no study of lymphatic spread of carcinoma of the breast that includes the contralateral internal mammary chain, Rouvière[11] states that the internal mammary lymphatics of one side can connect with those of the opposite side by a transverse retrosternal anastomosis usually at the level of the 1st intercostal space. Supraclavicular involvement by metastatic breast carcinoma is usually late, and we are led to think that it is always secondary to metastatic involvement of the highest axillary or subclavicular group of lymph nodes. No instance was found reported where this spread was from the internal mammary chain to supraclavicular nodes without involvement of the axillary and

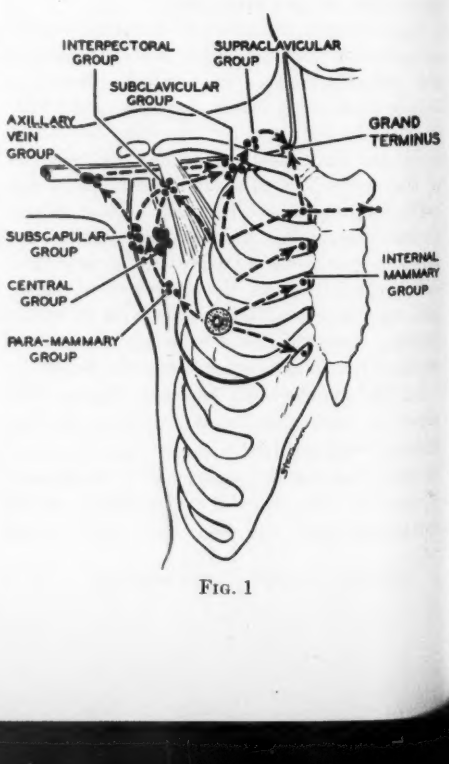

FIG. 1

subclavicular nodes, although lymphatic continuity exists between the internal mammary and supraclavicular chain.[9] According to Rouvière[11] no direct drainage from the breast to the supraclavicular nodes is present, the common filter being the subclavicular group of nodes (fig. 1).

With this information as a background we proposed to subject patients with carcinoma of the breast to the classical radical mastectomy and combine this with bilateral biopsy of the internal mammary chain through the superior three intercostal interspaces. The information obtained would be used as a guide for radiotherapy; those with positive internal mammary nodes receiving parasternal irradiation and those with positive axillary nodes would receive axillary and supraclavicular chain irradiation.

From November 1955 through December 1958, 48 patients have been operated upon for carcinoma of the breast (table 1). These operations were performed by 13 different house officers; 38 conventional radical mastectomies, 5 simple mastectomies and a simple mastectomy with axillary dissection were done. Two patients, both of whom had had prior radical mastectomies underwent internal mammary node biopsies in the presence of locally recurrent disease. One patient had a punch biopsy of her primary lesion plus an internal mammary chain biopsy; another with a far advanced stage IV carcinoma underwent a lesion biopsy and oophorectomy. Of the 48 patients, 28 had intercostal interspace exploration, either bilateral or on the ipsilateral side (table 2).

At the end of the 3-year period 8 of 48 patients (16.6 per cent) have died, of breast carcinoma; 6 (12.5 per cent) of these patients are living with recurrent disease. Of the 28 patients undergoing intercostal interspace exploration, 3 patients had positive biopsies, 2 of these are living without evidence of recurrent disease, 1 patient who died had a punch biopsy only of the primary lesion plus biopsy of the internal mammary chain. Fourteen patients had negative biopsy of the internal mammary chain. Of these 11 are living free of cancer, 2 have died of carcinoma and 1 is alive with metastatic disease. Eleven patients underwent biopsy of tissue in the intercostal spaces, but in these no lymphatic tissue was found upon histologic section. In this last group 6 patients are living free of disease, 3 are dead of carcinoma, and 2 are living with recurrent cancer.

One of the patients living with recurrent disease has been of particular interest. In April 1957 a radical mastectomy for carcinoma in the outer lower quadrant of the right breast was done along with bilateral exploration of the first 3 intercostal interspaces. Lymphatic tissue consisting of a node in each space was removed from the involved side. These sections were reported negative for metastatic carcinoma. The 3 contralateral spaces were explored, and areolar and fatty tissue was reported. Twenty months

TABLE 1

Operative procedures on breast carcinoma at University Hospital from November 1955 to January 1959

Procedure	No. of Cases
Conventional radical mastectomy	38
Simple mastectomy	5
Biopsy of internal mammary chain only	2*
Punch biopsy of primary lesion plus biopsy of internal mammary chain	1†
Biopsy of primary tumor and oophorectomy	1
Simple mastectomy with axillary dissection plus internal mammary node biopsy	1

* Both had had radical mastectomies before January 1956, one at University Hospital and the other at another Baltimore hospital.

† Nonresectable.

TABLE 2

Mastectomy with biopsy of internal mammary nodes

Procedure	No. of Cases
Radical mastectomy with biopsy in 1st, 2nd, 3rd interspaces on the same side as primary breast lesion	11
Radical mastectomy with biopsy bilateral in 1st, 2nd, 3rd inter spaces	9
Radical mastectomy with biopsy in 1st, 2nd, 3rd spaces on involved side and either in one or two of the first 3 spaces on opposite side	4
Radical mastectomy with biopsy in 2nd space only on involved side	1
Radical mastectomy with biopsy in 3rd space only on involved side	1
Radical mastectomy with biopsy in 1st and 2nd spaces bilaterally	1
Simple mastectomy with biopsy in 1st, 2nd, 3rd spaces on involved side	1

later it was noted that there was a nodule arising in the 4th interspace near the sternum of the side on which the breast carcinoma had existed preoperatively. There was visible on the roentgenogram destruction of the sternum in this area (figs. 2 and 3). This patient has since received radiation therapy to the site of regional metastasis.

Some of the factors relating to this incident were studied by Hutchinson and Kiriluk.[7] They concluded "that the incidence of local recurrence was greater after exploration and removal of the internal mammary lymph nodes as compared with a group in which no exploration of the internal mammary chain was done", and further that these patients died sooner. They felt that dissection in these spaces "stimulated the activity of carcinoma" and that "cancer in the internal mammary nodes probably lies dormant unless disturbed". In commenting upon the above statement, Haagensen and Obeid[3] emphasized the necessity of a meticulous operative

FIG. 2. Tumor nodule in parasternal area post-mastectomy.

FIG. 3. Destruction of sternum by parasternal tumor.

technique which includes the change of instruments, drapes, gloves and gowns when moving from a cancer-bearing area into tissue where the presence of metastasis is unknown.

In our single case either factor may have been significant in the postoperative appearance of metastatic tumor in the ipsilateral parasternal area. However, it is unusual for surface seeding to manifest itself after an interval of 20 months; moreover, the site of tumor growth is somewhat beyond the area of parasternal exploration but still within the confines of the surgical wound.

At the induction of this study it was anticipated that the application of postoperative radiation therapy would be predicated upon the presence of nodal involvement by metastatic disease and would be localized to the general areas where the disease was known to exist. The preceding case history indicates that this is not a valid restriction and should not be so considered unless exploration of each of the 5 homolateral spaces is undertaken. For this reason radiation therapy was not administered to the reported patients according to the previously outlined protocol. Instead, all patients who had positive nodes in either axillary or parasternal area were advised to have irradiation in the postoperative period. The value of this procedure then seems apparent only as a measure of the effectiveness of the irradiation given to an area known to have been occupied by lymphoid tissue containing metastatic tumor. On the presumption that removing such a node does not constitute a worthwhile effort toward eradication of all the metastatic tumor in this site, it seems valid.

SUMMARY

A preliminary study was initiated, in 1955, upon patients with breast carcinoma wherein efforts were made to define clearly the extent of regional lymph node metastases: This information was to be the basis for initiation of postoperative radiation therapy and for the sites of application of this modality. A basic assumption, that the administration of high energy radiation therapy in moderate to large dosage to small and well defined areas could sterilize effectively the lymphoid tissue in these fields which contained metastatic carcinoma, was made.

No instances have been found to date where contralateral internal mammary chain nodal involvement by metastatic carcinoma has occurred.

In one instance subsequent metastatic carcinoma appeared in one parasternal interspace below the site of a negative lymph node biopsy. This occurrence emphasizes the importance of a rigidly adhered to regime to prevent implantation of carcinoma cells at the site of such biopsies at the time of mastectomy. However, there is no proof at hand that the later appearance of carcinoma in the parasternal area of this one patient did not take place from tumor cells within intercostal lymph channels and in a lymph node beyond the site of biopsy.

It seems evident that the removal of nodal tissue from the upper 3 spaces is insufficient evidence that all the homolateral parasternal nodes are free of metastatic disease.

This study will be continued in order to determine more clearly its usefulness in the localization of metastatic carcinoma at the time of mastectomy.

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ABDOMINAL SYMPTOMS FROM OBSCURE UROLOGIC CONDITIONS IN CHILDHOOD*

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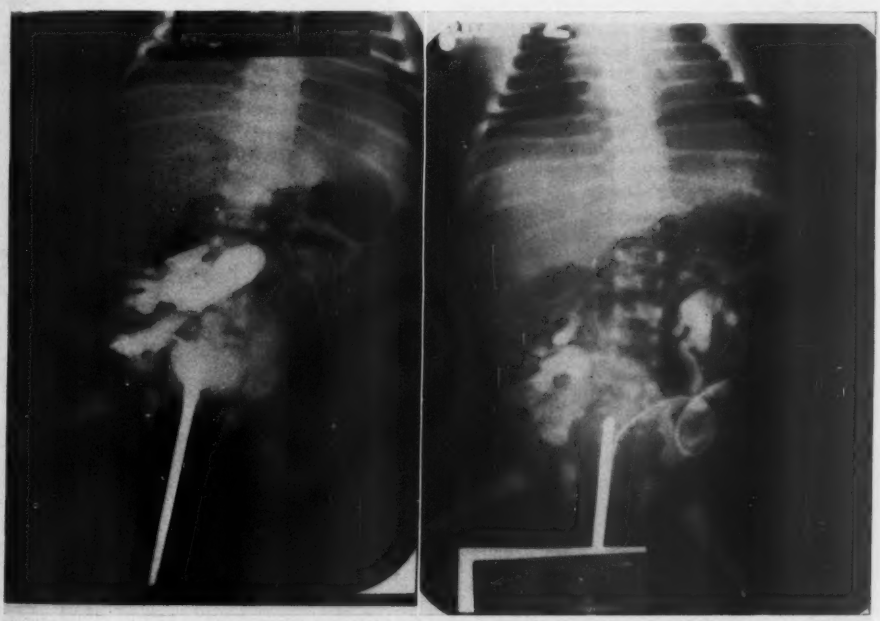
The source of abdominal symptoms is not always easily discovered in the child. The frequency with which the urinary tract can be the cause of such symptoms has been emphasized by both urologists and pediatricians. Disease in the urinary tract is a relatively frequent cause of nausea, vomiting, abdominal pain, constipation, anorexia, and abdominal masses.[1] Failure to recognize this system as a possible factor in abdominal complaints might result in unnecessary laparotomy and further delay in the proper treatment.

A review of the inpatient children seen in the Division of Urology at the University Hospital for the years 1952 through 1957 showed that 43 pediatric patients found to have primary urologic disease exhibited one or more of the above signs and symptoms as a major part of their clinical picture. Abdominal pain was listed as a complaint in the history of 27 of the 43 patients. Nine patients had only abdominal symptoms, and 5 patients had an abdominal mass as an only sign of illness.



FIGS. 1 AND 2 (Case 1). FIG. 1 (*left*), a right retrograde pyelogram showing hydro-ureteronephrosis. FIG. 2 (*right*), a left retrograde pyelogram.

The abdominal mass should direct the clinician's attention immediately to the urinary tract. Hydronephrosis is perhaps the commonest of all abdominal masses in children. Wilms' tumors and neuroblastomas are among the most important but are not the most common found in the abdomen of the young child. A state of near-panic has been precipitated in some

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quarters by the finding of an abdominal tumor in a baby. We have learned not to rush into the abdomen to treat a mass before the urinary tract has been adequately visualized.

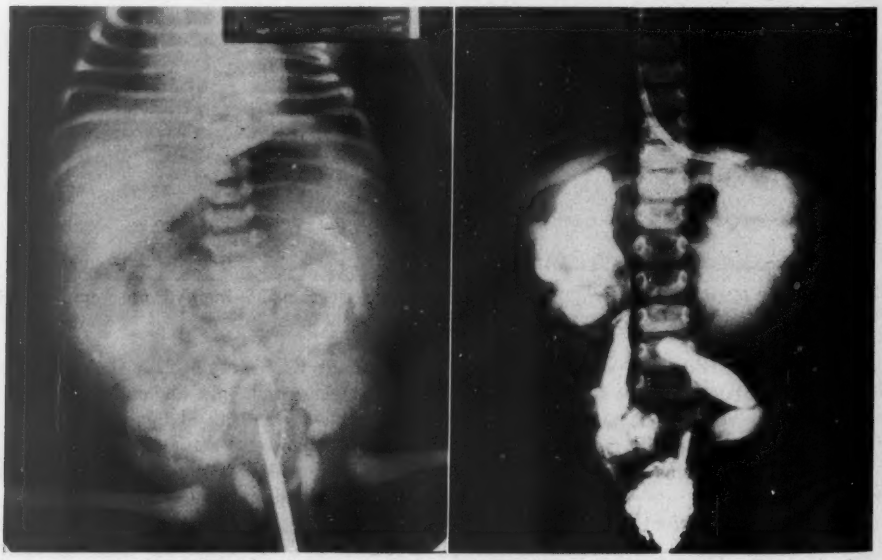
CASE REPORTS

Case 1. Baby boy H. (U.H. 084074) was seen in the newborn nursery a few hours after birth because of a mass in the right flank and a mass in the lower abdomen. Catheterization confirmed the impression that the lower abdominal mass was a distended bladder. Retrograde pyelograms showed a bilateral hydroureteronephrosis (figs. 1 and 2). Suprapubic cystostomy and an exploration of the right flank mass were performed. The right flank mass was found to be a solitary cyst of the kidney, the redundant portion of which was removed. This child later succumbed to additional anomalies of the pulmonary tree. Autopsy showed congenital valves in the posterior urethra (fig. 3).

Case 2. Baby boy M. (U.H. 138832) was seen 2 days after birth because of bilateral flank masses. A retrograde pyelogram revealed distortion of the collecting system indicating polycystic disease (fig. 4). The patient succumbed within a few days with renal failure.

Case 3. V. H. (U.H. 011122) was a 2-year-old male child who presented with abdominal disten-

FIG. 3 (Case 1). Autopsy specimen showing cusplike valves extending from veru in prostatic urethra and marked hypertrophy of bladder from obstruction.



FIGS. 4 AND 5 (Cases 2 and 3). FIG. 4 (*left*), a left retrograde pyelogram showing pelvic and calyceal distortion in polycystic kidney. FIG. 5 (*right*), a bilateral retrograde pyelogram showing hydro-ureteronephrosis as cause of "abdominal distension" for which a Levine tube (gastric) had been inserted. Residual barium present from enema.

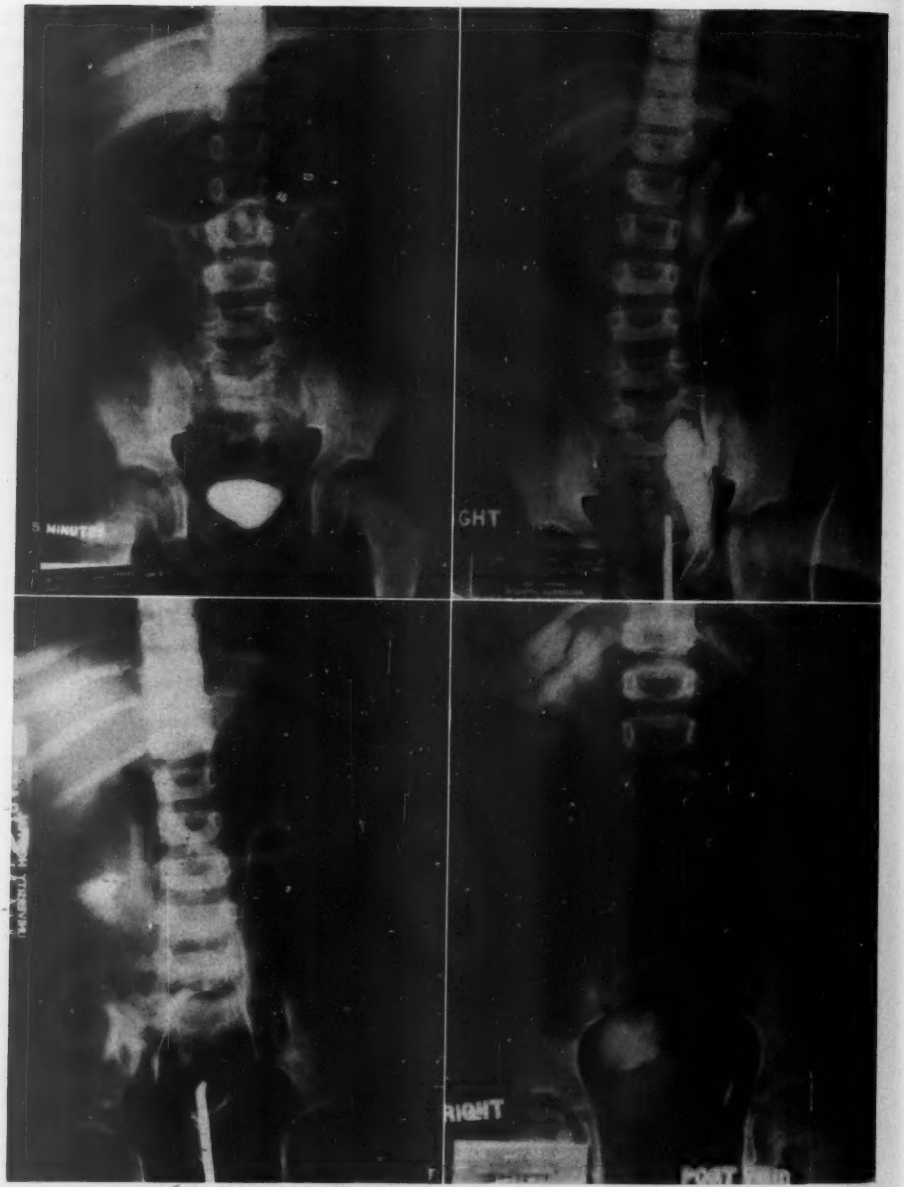
tion and constipation. There were no other symptoms. The urine was microscopically negative. A bilateral hydronephrosis was found (fig. 5).

Abdominal pain, alone or associated with other symptoms, was a major complaint in many of the children with urologic disease. Three of these patients had emergency laparotomies for suspected acute intraperitoneal pathology. A correct diagnosis was delayed in some of the other children until some additional symptom directed the attention of the clinician to a urinary tract disorder. Obstructive uropathies were the most frequent findings in this group of patients.

Case 4. J. K. K. (U.H. 71451) was a 5-year-old boy who had recurrent left lower quadrant pain since birth. A barium enema had been normal. The physician's attention was directed to the urinary tract by one episode of hematuria. An intravenous pyelogram showed a left hydronephrosis from a ureteropelvic junction obstruction (fig. 6). This child had no urinary symptoms.

Case 5. C. W. (U.H. 017929) was a 5-year-old girl who had been seen in the accident room 1 year before her admission because of abdominal pain and a watery vaginal discharge. This child had been punished by her parents for bed-wetting. The source of confusion in this patient was her voiding of normal amounts of urine at normal intervals with continuous dribbling in between voidings. Urologic survey 1 year after she was first seen showed a bifid renal pelvis on the left side (fig. 7). Further study revealed a ureteral orifice opening into the urethra distal to the sphincter.

FIG. 6 (Case 4). Excretory urogram (30-minute film) showing left ureteropelvic obstruction



FIGS. 7 TO 10. FIG. 7 (Case 5), *upper left*. Excretory urogram showing bifid collecting system on left. FIG. 8 (Case 5), *upper right*. A left retrograde pyelogram showing hydro-ureter which opened into urethra from left upper segment. FIG. 9 (Case 6), *lower left*. A retrograde urogram showing a right hydronephrosis in child explored for "acute abdomen". FIG. 10 (Case 7), *lower right*. Excretory urogram showing right hydro-ureter in child operated on for suspected acute appendicitis. A persistent umbilical artery was found.

Pyeloureterograms revealed a normal ureteral orifice opening in a normal position on the left side in addition to the ectopic orifice. The pyelogram showed a marked hydroureter leading from the ectopic orifice into the upper segment of the bifid pelvis on the left (fig. 8). A heminephrectomy relieved her pain and incontinence.

Case 6. F. M. (U.H. 74203) was a 5-year-old child admitted to Dr. H. B. Mays because of nausea, abdominal pain, distention and fever of 12 days' duration. Exploration at the beginning of his illness had revealed a retroperitoneal mass which was aspirated and found to contain urine. Subsequent urologic survey showed a right hydronephrosis for which a nephrectomy was performed (fig. 9).

Case 7. A. M. (U.H. 142697) was a 10-year-old child who had an emergency appendectomy performed on November 8, 1957, for right quadrant pain and a negative urine. The appendix was found to be normal. A retroperitoneal mass was found. A marked right hydroureter and hydronephrosis secondary to compression of the lower ureter from a persistent umbilical artery was found and corrected (fig. 10).

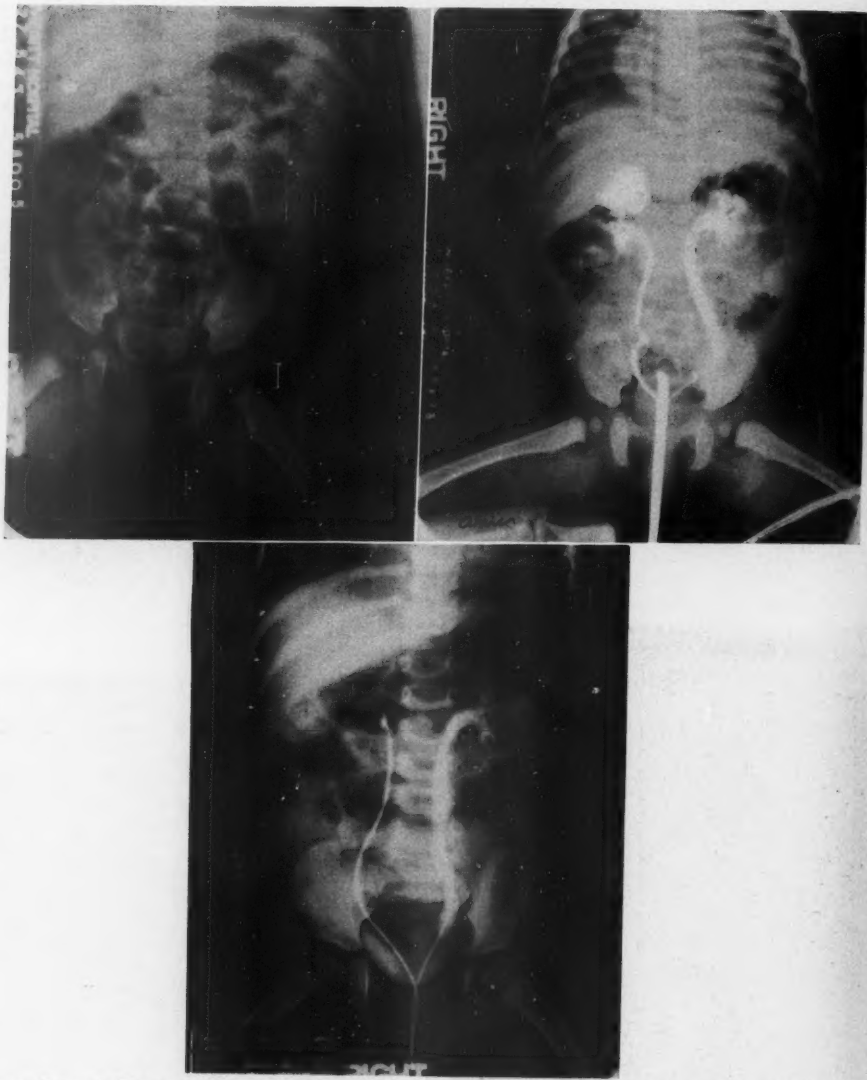
Case 8. R. T. (U.H. 108253) was admitted to Dr. John F. Hogan, Jr., on November 9, 1956, because of abdominal pain, vague low back pain, weight loss, fever and some hematuria. There was a questionable palpable mass in the left upper left side with the upper ureter ending in a ureterocele (fig. 11). This child was relieved by a left heminephroureterectomy.

Case 9. R. S. (U.H. 107341) was admitted to the service of a general surgeon on October 8, 1956, because of left lower quadrant pain and vomiting. There was tenderness in the left upper quadrant. Urinalysis showed red blood cells too numerous to count. Urologic consultation was requested. A stone was found in the left ureter on excretory urography and a left ureterolithotomy was performed (fig. 12).

Case 10. R. M. (U.H. 025172) was a 22-month-old girl who was admitted because of vomiting, fever, urinary frequency and failure to gain weight. She had been previously studied on another service about 1 year before admission. At that time, the right renal parenchyma was perforated with a ureteral catheter and there was subcapsular extravasation of the contrast medium (figs. 13 and 14). The kidney was explored, and no pathology was found. The child was admitted to the urologic service on May 20, 1955, or about 1 year later. Intravenous pyelograms showed no visualization of the right kidney. Catheterization of the right ureter revealed no filling of the right kidney (fig. 15). Exploration of the right kidney at this time revealed only a very tiny nodule of tissue at the upper end of the ureter. This case presents apparently a true autonephrectomy from

FIG. 11 (Case 8). Left retrograde pyelogram showing hydro-ureter ending in ureterocele from upper segment of bifid collecting system.

FIG. 12 (Case 9). Excretory urogram showing stone in lower left ureter.



FIGS. 13 TO 15 (Case 10). FIG. 13 (*top left*), normal excretory urogram but showing poor detail FIG. 14 (*top right*), retrograde pyelogram showing subcapsular extravasation of contrast medium upper pole right kidney. FIG. 15 (*bottom*), retrograde pyelogram showing no right renal pelvis 1 year later.

injury secondary to perforation by a catheter and/or surgical exploration.

Case 11. F. L. (U.H. 092033) was a 12-year-old boy who had been studied on several occasions for bilateral costovertebral angle pain. He had occasional microscopic hematuria. There was no renal outline apparent on the left side. Catheterization of the left ureter was unsuccessful above the level of the pelvic brim (fig. 16). Eventual exploration revealed a multicystic atrophic left kidney (fig. 17).

The abdominal symptoms secondary to urethral obstruction and infection are to be emphasized. Campbell[1] and Hodges[2] have written about the infection in the female urethra as the cause of abdominal pain and recurrent urinary infections. The periurethral glands of the female urethra are the foci for chronic infection in this area. We have seen many children, particularly girls, relieved of lower abdominal symptoms by urethral dilations and antimicrobial therapy.

Case 12. K. B. (U.H. 081281) was seen because of recurrent abdominal pain and fever. She was found to have a residual urine of 400 cc. An excretory urogram showed no visualization of the right kidney and a dilation of the collecting system on the left side (fig. 18). After catheterization, the left hydroureter immediately disappeared (fig. 19). A cystogram showed a dilated bladder but no evidence of ureterovesical reflux (fig. 20). A right hydronephrotic kidney was removed. The residual urine disappeared after treatment by dilation of the chronic urethritis.

FIG. 16 (Case 11). Retrograde ureterogram showing filling of only lower ⅓ of left ureter.

FIG. 17 (Case 11). Multicystic left kidney removed from case 11.

The small urethral meatus in the male child is a common obstructive lesion. Treatment by a simple meatotomy can be very gratifying.

Case 13. T. V. (U.H. 070980) was admitted to the hospital because of acute abdominal pain and distention. The bladder was palpated. An excretory urogram showed slight dilation of both lower ureters (fig. 21). The child's urinary obstruction and associated symptoms were relieved by a meatotomy of a near pin-point urethral meatus.

SUMMARY

Illustrative cases of abdominal symptoms caused by urologic disease are presented. Some

FIGS. 18 TO 20. (Case 12). FIG. 18 (*top left*), one-hour excretory urogram showing distended bladder and left hydro-ureteronephrosis. FIG. 19 (*top right*), film showing good drainage of left side following catheterization immediately after film in figure 18. FIG. 20 (*bottom*), cystogram showing large bladder but no reflux.

FIG. 21 (Case 13). A 30-minute excretory urogram showing mild hydro-ureters secondary to urinary retention from stenosis of urethral meatus.

of these patients had only abdominal symptoms. Three of them had urologic disease discovered at abdominal laparotomy. The importance of urologic survey in the child with unexplained abdominal complaints is apparent. The significance of chronic urethritis in girls and stenosis of the urethral meatus in boys as a cause of unexplained symptoms has been stressed.

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AN APPRAISAL OF THE ROUTINE POSTOPERATIVE USE OF PANTOTHENYL ALCOHOL FOR PREVENTION OF INTESTINAL ATONY

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Intestinal atony is one of the serious complications associated with major abdominal surgery. Chemical and physical measures for coping with this problem have been disappointing. For example, in many of the large university hospitals, and even more so in the smaller community hospitals, only 6 or 7 Miller-Abbott tubes out of every 10 passed will enter the duodenal loop and continue past the ligament of Treitz. The remaining 30 or 40 per cent coil up in the stomach and fail to enter the antrum of the stomach even when controlled under direct vision (fluoroscopy). The hyperperistalsis and overstimulation, characteristic of neostigmine and other cholinergic drugs, make them very unsatisfactory enterokinetic agents. However, the advent of a new enterokinetic agent, *d*-pantothenyl alcohol, offers much promise, not only in the treatment of intestinal atony, but also in its prevention.

d-Pantothenyl alcohol* is the alcohol analog of pantothenic acid. After intramuscular administration, it is rapidly converted in the living body to pantothenic acid.

The role of pantothenic acid in gastrointestinal functions has been extensively investigated. Bly and associates[2] observed a 50 per cent decrease in gastrointestinal motility in enterostomized dogs on a pantothenate-deficient diet. Supplementation with the vitamin resulted in the resumption of normal peristalsis. Jurgens and Pflatz[3] created a panthothenic acid deficiency in rats; the bowel became distended, and there was a loss of peristaltic movement. After administration of pantothenic acid, distention disappeared and normal bowel motility was restored. The biochemical function of pantothenic acid and its recognition as the active principle of the coenzyme A molecule essential to acetylation was elucidated by Lipmann.[10] Olson and Kaplan[11] demonstrated a 25 to 40 per cent depletion of coenzyme A content in rats and ducks maintained on a panthothenic acid-deficient diet. Bean[11] observed a fall in acetylation in humans in conditions of pantothenic acid deficiency together with alterations in carbohydrate metabolism, blood cholesterol, steroid hormone excretion, plasma protein and failure of adrenocorticotrophic hormone to produce eosinopenia. Rolli[13] discovered evidence of the importance of pantothenic acid in stress conditions imposed on human subjects. The relationship between pantothenic acid and intestinal function seems to involve the following sequence of events. Pantothenic acid is incorporated into the coenzyme A molecule; coenzyme A and choline acetylase catalyze the formation of acetylcholine from choline and acetate. The release of acetylcholine at the postganglionic parasympathetic fibers provides the natural stimulus for the control and instigation of gastrointestinal activity. Pantothenic acid deficiency correlates with decreased acetylcholine production. Relating this phenomenon to the clinical problem of intestinal atony, Stone and associates[15] postulate that surgical stress, circulatory disturbance and infection deplete the body's pantothenic acid stores, thereby setting the stage for ileus. There is a plethora of clinical reports attesting to the value of *d*-pantothenyl alcohol in the treatment and prevention of postoperative intestinal atony.[4-7, 9, 12, 14, 16, 17]

Haycock and associates[6] conducted a double blind study with pantothenyl alcohol in 100 surgical patients, 50 of these serving as controls. Postsurgical distention, nausea and vomiting were significantly reduced, and peristaltic activity returned earlier in the pantothenyl-treated patient. Stone and his colleagues[15] had excellent results in 130 patients who received *d*-pantothenyl alcohol. In addition to earlier resumption of peristalsis, postoperative bladder retention was markedly diminished. The most recent publications by Frazer and co-workers[5] and Turow[16] corroborate the usefulness of pantothenyl alcohol in the postsurgical patient especially after major abdominal operations. It appears to be equally effective in preventing the development

* Supplied as Cozyme by Travenol Laboratories, Inc., Morton Grove, Illinois.

of intestinal atony and in overcoming even profound adynamic ileus. All investigators concur in the very fortunate feature of this medication; it has shown a complete freedom of local or systemic undesirable effect. As a corollary of its mechanism of action, it has not produced hyperperistalsis and intestinal cramping.

PRESENT CLINICAL STUDY

Stimulated by the previously discussed encouraging results of other investigators with *d*-pantothenyl alcohol, we adopted its use routinely in 147 patients undergoing major surgery. A control series consisting of 35 patients having had surgery equivalent to the treatment group was also included in the evaluation.

METHODS

The dosage schedule consisted of an intramuscular injection of 2.0 cc. (500 mg.) of *d*-pantothenyl alcohol immediately after surgery, repeated 2 hours later, and thereafter at intervals of 6 hours until peristalsis returned. Prompted by the possibility that an initial dose of 4.0 ml. may produce a more rapid response, we employed this dose in 20 patients, postoperatively; peristaltic response could not be hastened beyond what had been reported in the literature with the 2.0-cc. dose. The larger dose, although well tolerated, was discontinued.

MATERIAL AND RESULTS

Table 1 shows the type of operation and its frequency, to bring out any relation between the surgical procedure and return of peristalsis.* Table 2 shows the same criteria for the control group of 35 patients who did not receive preventive injections of *d*-pantothenyl alcohol. Figure 1 permits a direct visual comparison and shows clearly the advantage of *d*-pantothenyl alcohol. In the treated group, return of peristalsis was accomplished in 89.8 per cent of the patients within 24 to 48 hours and in 10.2 per cent within 48 to 60 hours. No patient showed atony after 60 hours. The respective figures in the control group show return of peristalsis in only 11.4 per cent within 24 to 48 hours, 34.3 per cent within 48 to 60 hours and in 54.3 per cent after 60 hours. In all of these patients an intestinal atony of varying degree of severity developed which was successfully relieved with *d*-pantothenyl alcohol. The diagnosis of ileus was based on abdominal auscultation and roentgenograms.

TABLE 1

d-Pantothenyl alcohol group

Type of Operation	No. of Operations	Return of Peristalsis after First Dose	
		Within 24 to 48 hr.	Within 48 to 60 hr.
Repair of ruptured duodenal ulcer	3	3	
Subtotal gastrectomy	7	5	2
Total hysterectomy	15	14	1
Cholecystectomy	12	12	
Presacral neurectomy	7	7	
Umbilical hernia	5	4	1
Salpingo-oophorectomy	1	1	
Strangulated inguinal hernia-involvement small bowel	1		1
Appendectomy	28	23	5
Femoral hernia	2	2	
Inguinal hernia	12	11	1
Appendectomy combined with ventral suspension	4	4	
Incision and drainage ischiorectal abscess	3	3	
Vaginal plastic repair	8	6	2
Removal large bowel tumor (primary anastomosis)	1	1	
Incisional hernia repair	6	6	
Hemorrhoidectomy	13	12	1
Excision of fistulous tract small bowel-primary anastomosis	1	1	
Bilateral cutaneous ureterostomy	1	1	
Excision of ruptured intervertebral disk	3	3	
Excision of entire abdominal wall left upper quadrant (benign tumor)	1	1	
Lumbar sympathectomy	13	12	1
Total	147	132	15

The following case report, selected from the control group, representatively illustrates the typical sequence of events as it occurred in this group postoperatively (*viz.*, development of ileus

* Ascertained by auscultation over all quadrants of the abdomen.

TABLE 2

Control group

Type of Operation	No. of Operations	Return of Peristalsis after First Dose		
		Within 24 to 48 hr.	Within 48 to 60 hr.	After 60 hr.
Hemorrhoidectomy...	3	1	1	1
Total hysterectomy.....	10		4	6
Appendectomy.....	11	3	4	4
Lumbar sympathectomy.....	6		1	5
Cholecystectomy.....	5		1	4
Total	35	4	12	19

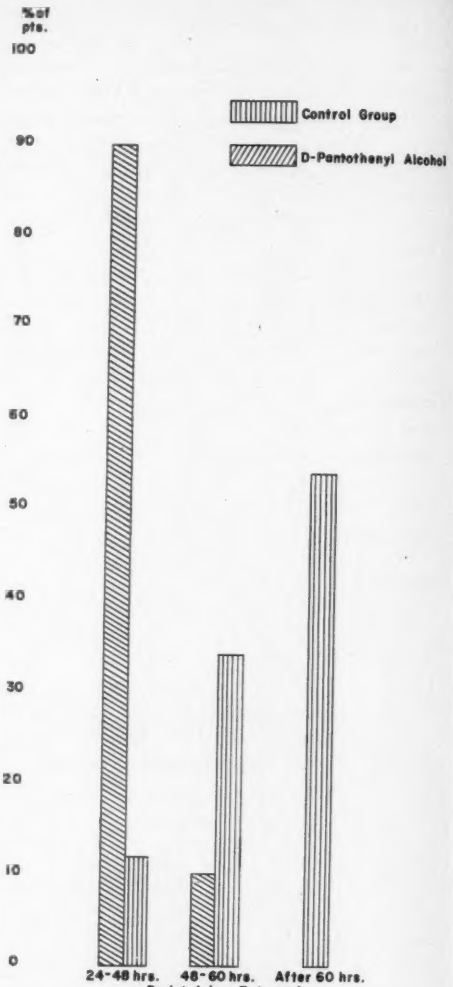

FIG. 1

and its successful management with *d*-pantothenyl alcohol):

CASE REPORT

C. M., a 36-year-old white woman, was admitted to the hospital on February 28, 1958, with a chief complaint of menometrorrhagia. Examination revealed a fibroid uterus. A total hysterectomy was performed on March 1, 1958, leaving the fallopian tubes and ovaries in place. The postoperative course was uneventful for the first few days, except for a low-grade temperature. During the entire postoperative course, the patient was recalcitrant and uncooperative, removing her Foley catheter and refusing to follow the usual postoperative routine. On the 5th postoperative day, a low-grade adynamic ileus developed characterized by abdominal pain, diminished peristalsis and abdominal distention. A flat film confirmed the diagnosis. A Miller-Abbott tube was passed but was removed by the patient on the evening of the same day. On the 6th postoperative day, the Miller-Abbott tube was passed again. Electrolyte balance was maintained with intravenous fluids. Fluid intake and output were carefully recorded. Serial x-rays continued to show a moderate degree of small bowel distention and a small degree of large bowel dilation. A rectal tube was ordered to be used when required and a hot water bottle applied to the patient's abdomen. On the 7th postoperative day, in addition to the above routine, the patient was placed on *d*-pantothenyl alcohol therapy as follows: 2.0 cc. were given intramuscularly, with a 2nd dose 2 hours after the first injection. The 3rd dose was given 8 hours later. On the 8th postoperative day, 18 hours after the administration of the first dose, the patient passed flatus freely, and it was possible to clamp off the Miller-Abbott tube. *d*-Pantothenyl alcohol therapy was continued with excellent results, and the following morning the Miller-Abbott tube was removed. The remainder of the postoperative course was uneventful, and the patient was discharged on the 15th postoperative day.

The experience of other authors who found a greatly reduced incidence of bladder retention and gratifying absence of undesirable side effects was corroborated in our series.

DISCUSSION

Christopher[3] sagely observes, "It is easier to prevent ileus than to overcome it." Furthermore, he states, "Apparently, the predisposition mechanisms for some degree of ileus are present in every abdominal procedure. The alternative is to interrupt the cycle leading to clinical ileus or to accept a high incidence of this complication and rely on being able to cope with it." Based on our successful clinical trials with *d*-pantothenyl alcohol and the favorable reports of other investigators using the drug to prevent ileus, we believe it to be the ideal enterokinetic agent for prophylaxis in this condition. Careful consideration of each of the various chemotherapeutic agents that have been used to counteract ileus highlights their marked disadvantage, particularly where compared with *d*-pantothenyl alcohol germane to side effects. Pituitrin and Pitressin may produce a severe myocardial ischemia, and their use in the patient of "coronary age" is inherently dangerous. Contraindications to the use of neostigmine are pregnancy, asthma, peritonitis, mechanical intestinal obstructions, hyperthyroidism, heart disease of any type, a vesical neck obstruction, hypertrophy or tumors of the prostate, urethral strictures, severe posttraumatic or postoperative edema, obstructions caused by intravesical stones and old age. The disadvantages to bethanechol chloride are the same as those for neostigmine.[1] Thus when these medicaments are compared with *d*-pantothenyl alcohol, the striking advantages of this agent are immediately apparent. Owing to its demonstrated effectiveness in the prevention of intestinal atony and its lack of side effect, we recommend it as the preferred drug for routine prophylactic administration after all abdominal surgery.

SUMMARY

In a series of 182 patients, *d*-pantothenyl alcohol (2.0 cc.) was administered intramuscularly to 147 immediately after abdominal surgery, repeated in 2 hours and followed by similar doses every 6 hours until resumption of peristalsis. The remaining 35 patients acted as a control group. The advantages of prophylactic *d*-pantothenyl alcohol administration are clearly shown by the following results:

Resumption of peristalsis occurred within 24 to 48 hours in 89.9 per cent of patients receiving *d*-pantothenyl alcohol; none showed evidence of intestinal atony beyond 60 hours postoperatively. Of the control group, only 11.4 per cent resumed peristalsis within 24 to 48 hours; 34.3 per cent required 48 to 60 hours and 54.3 per cent more than 60 hours. Eleven of these patients developed adynamic ileus, which responded successfully to *d*-pantothenyl alcohol therapy. Moreover, there was complete absence of side effects, early resumption of oral feeding, greatly reduced use of enemas, less nausea and vomiting and reduced incidence of urinary retention.

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EXPERIENCES WITH THE ROBERTSON URINE TEST*

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Robertson has described a test for the detection of cancer based on observation of a peculiar action of blood from a cancer patient's urine. Dr. Robertson reported the high incidence of formation of a peculiar clot which clings to the bottom of a dish when the blood of a cancer patient is mixed with his own urine.

TABLE 1

Diagnosis	How Established	Results of Urine Test
Squamous cell cancer (skin)	Biopsy	−*
Adenocarcinoma (stomach)	Operative biopsy	+*
Cancer (breast)	Operative frozen section	+
Squamous cell cancer (lip)	Biopsy	+
Cancer (breast)	Operative frozen section	−
Squamous cell cancer (nasopharynx)	Biopsy	+
Squamous cell cancer (jaw)	Biopsy	+
Squamous cell cancer (parotid)	Biopsy	−
Cancer (breast)	Operative frozen section	−
Cancer (lip)	Biopsy	−
Fibrosarcoma (scalp)	Biopsy	−
Cancer (breast)	Operative frozen section	+
Cancer (breast with axillary metastasis)	Operative frozen section	−
Basal cell cancer (skin)	Biopsy	−
Squamous cell cancer (larynx)	Biopsy	−
Squamous cell cancer (tonsil and floor of mouth)	Biopsy	−
Squamous cell cancer (nasopharnyx)	Biopsy	−

TABLE 1—*Continued*

Diagnosis	How Established	Results of Urine Test
Squamous cell cancer (skin)	Operative biopsy	+
Basal cell cancer (skin)	Biopsy	+
Popliteal adenocarcinoma (breast)	Operative frozen section	+
Recurrent branchial cancer (neck)	Biopsy	+
Squamous cell cancer (skin)	Biopsy	−
Squamous cell cancer (tonsil)	Biopsy	−
Squamous cell cancer (axillary nodes)	Biopsy and resection	+
Sarcoma (abdominal wall)	Radical resection	+
Fibroadenoma (breast)	Operative biopsy	−
Fibroadenoma (breast)	Operative biopsy	−
Fibroadenoma (breast)	Operative biopsy	−
Maxillary cyst	Operative biopsy	+
Maxillary cyst	Operative biopsy	−
Gynecomastia	Operative biopsy	+
Fibroadenoma (breast)	Operative biopsy	−
Benign cyst (scalp)	Operative biopsy	−
Epithelial cyst	Operative biopsy	−
Gynecomastia	Operative biopsy	−
Granuloma (tongue)	Operative biopsy	+
Benign tumor (jaw)	Operative biopsy	+
Leukoplakia (mouth)	Operative biopsy	−
Benign tumor (tongue)	Operative biopsy	+
Benign tumor (nasopharynx)	Operative biopsy	+
Gynecomastia	Operative biopsy	+
Leukoplakia (mouth)	Operative biopsy	−
Hyperkeratosis (lip)	Operative biopsy	+
Leukoplakia (mouth)	Operative biopsy	−
Benign nevus	Operative biopsy	−
Benign breast	Operative biopsy	+
Benign breast	Operative biopsy	+
Benign breast	Operative biopsy	+
Benign breast	Operative biopsy	+
Benign breast	Operative biopsy	+

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* − indicates negative findings; + indicates positive findings.

Because this test appeared to be of interest and of possible value in screening patients for the presence of malignant tumors, it was performed in a preliminary series of nonselected patients. All patients seen in the tumor clinic in 1953 were submitted to the test before biopsy. The test was performed as described by Dr. Robertson.

Blood (5 cc.) is inserted beneath a mixture of lime water (5 cc.) and urine (60 cc.) so that it lies at the bottom of the basin. After 5 minutes the presence of a clinging clot signifies a positive test. The diagnosis of each patient was established by pathologic examination of a biopsy or operative specimen.

A series of 50 consecutive patients were tested, 25 malignant and 25 benign lesions, and the results are summarized in table 1. It should be noted that there are about equal numbers of false-positive reactions and false-negative reactions. The test was not performed in any patient after cancer had been resected so that positive reactions could not be interpreted as indicating a continuing but nondetectable disease. Of greatest interest is the false-negative reaction in patients proven to have active malignant disease.

SUMMARY

The Robertson test was performed on the blood and urine of 50 patients. In our experience, the test as described seems to be useless for screening patients for the presence of malignant disease since it was negative in over half of the patients with proved cancer.

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SURGICAL TREATMENT OF TWENTY PATIENTS WITH GROSS HEMORRHAGE FROM PRESUMED DIVERTICULAR DISEASE OF THE COLON*

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In an analysis of the records at the Charity Hospital of Louisiana in New Orleans, during the 15-year period ending in 1957, 78 patients were selected for study who required admission to the hospital because of gross hemorrhage, believed to have originated from diverticular disease of the colon.[1] All patients were initially treated conservatively, but 18 subsequently underwent operation because of uncontrolled bleeding, recurrent severe hemorrhage, or failure to exclude a diagnosis of carcinoma. Two other patients who were operated on for presumed bleeding diverticular disease but in whom another source of bleeding was found later, were added, bringing the total number of cases reviewed to 20.

In 5 patients operation was performed because carcinoma could not be excluded on roentgenography. All 5 manifested evidence of diverticulitis, presumably the source of the hemorrhage. Three had left colectomies; one, segmental resection of the sigmoid; and one, exploratory laparotomy. The one death occurred on the 18th day after left colectomy from multiple causes, including wound dehiscence, secondary bronchopneumonia, and general debility. In 2 patients, results of the left colectomy were satisfactory; neither patient has had any bleeding during follow-up periods of 26 months and 7½ years, respectively. As might be expected, the patient who had merely an exploratory laparotomy has continued to have recurrent hemorrhage. He has refused further surgical treatment. The patient who had segmental resection of the colon likewise has had an unsatisfactory result; recurrent hemorrhage required rehospitalization on one occasion. This patient, in addition to having an area of segmental diverticulitis in the sigmoid colon, had evidence of extensive diverticulosis of the left colon. Since so many patients with bleeding diverticular disease demonstrate on roentgenographic examination only the presence of diverticulosis, the area of segmental diverticulitis does not necessarily mean that this is the site of the hemorrhage. Left colectomy might well have given this patient a better final result.

In 9 cases operation was performed because of recurrent hemorrhage presumably resulting from diverticular disease of the colon. In all 9, only diverticulosis was demonstrated on roentgenographic and pathologic examination. There is one known incorrect diagnosis in this group. This patient had colectomy but continued to have repeated episodes of hemorrhage postoperatively and subsequently manifested definite evidence of ulcerative colitis in the remaining rectal segment. One other patient had colectomy, as the diverticular disease extensively involved the colon, and he has had no bleeding during the 15 months since the operation. In 6 patients left colectomy was performed with one operative death resulting from pulmonary infarct on the 3rd postoperative day. Of the 5 patients surviving operation, 2 have been lost to follow-up and the other 3 have had no recurrent hemorrhage for 10 months, 1½ years and 6½ years, respectively. One patient has had no recurrent hemorrhage during the 15 months since right colectomy.

Of particular interest are the cases that required emergency surgical therapy for uncontrolled bleeding. These will be described in more detail.

CASE REPORTS

Case 1. A 79-year-old Negro man was admitted to Charity Hospital in New Orleans because of repeated passage of bright red blood from the rectum for one day. The hematocrit was 17. In spite of multiple transfusions, active bleeding continued. Diagnostic studies, including proctoscopic examination, barium enema, and upper gastrointestinal roentgenography, revealed only extensive diverticulosis of the entire colon and questionable prepyloric ulcer. Active bleeding continued for 10 days after admission. At exploratory laparotomy and gastrostomy the bleeding point could not be located. The patient continued to bleed, and 2 days later the abdomen was re-

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explored. Gastrostomy, jejunostomy and ileostomy were performed without finding evidence of blood in these viscera. Total colectomy with anastomosis of the ileum to the rectum was then done. The resected colon was filled with fresh and old blood and contained extensive diverticulosis. The bleeding point was not demonstrated. Bloody stools ceased, but the patient died on the 3rd postoperative day, failing to rally from the operative procedure. Altogether he had received 20 pints of blood during his hospital stay. At necropsy no further evidence of intestinal bleeding was found.

Case 2. This patient was admitted for the 5th time for recurrent gross hemorrhage presumably from diverticulosis involving mainly the left side of the colon. Results of previous gastrointestinal studies had been negative. In spite of conservative therapy, active bleeding continued. Because of her poor general condition right transverse colostomy was performed. Intermittently, bleeding continued postoperatively but bleeding finally ceased with conservative therapy. On subsequent roentgenographic studies, upper gastrointestinal disease was found, and this is thought to be the source of her bleeding.

Case 3. An 84-year-old patient was admitted to Charity Hospital in New Orleans with passage of grossly bloody stools. In spite of receiving 24 pints of blood, active bleeding continued. Proctoscopy was difficult, and the examination was unsatisfactory. Barium enema was attempted 3 times without success. Aspiration of the stomach by Levin tube revealed no evidence of gross blood. On the 12th day after admission, shock developed, with continued passage of bloody stools. At operation, extensive diverticulosis of the left side of the colon was noted, and left colectomy was performed. Examination of the resected specimen revealed extensive diverticulosis filled with fresh and old blood. The patient died 6 hours after operation, apparently from shock. Postmortem examination failed to reveal any other significant pathologic changes.

Case 4. A 56-year-old Negro man was admitted to the hospital because of abdominal cramps followed by passage of maroon and bright red bloody stools, of one day's duration. Despite 13 blood transfusions, bleeding continued. Results of proctoscopic examination were negative. Barium enema examination revealed diverticulosis of the right side of the colon. On the 5th day, at laparotomy, no blood was noted in the stomach or small intestine. Right colectomy was performed. Bleeding ceased, and the patient recovered without incident. On pathologic examination of the resected specimen, numerous diverticula of the colon were seen, filled with bright red blood. Two small, pedunculated and nonulcerated polyps were found in the cecum but were not thought to be the source of bleeding. This patient has had no recurrent bleeding during the 16 months since operation.

Case 5. A 52-year-old Negro man was admitted to Charity Hospital during his first episode of bright red and maroon bloody stools. He was given 7 pints of blood in the next 48 hours. Bleeding continued. At laparotomy and gastrostomy on the 3rd day, no blood was seen in the stomach. The colon was filled with blood, but the abdomen was closed without doing anything further. Postoperatively, bleeding continued. Diagnostic studies including proctoscopic examination and barium enema, were carried out while the patient continued to receive 7 more pints of blood. These studies revealed only diverticulosis of the colon, more extensive on the right side than on the left. On the 6th day after admission, left colectomy was performed, leaving only the lower third of the sigmoid present. On examination of the resected specimen, diverticulosis was considered the only possible source of the bleeding. Bleeding ceased postoperatively, and the patient has had no recurrent hemorrhage during the ensuing 12 months.

Case 6. A 65-year-old Negro woman was admitted because of passage of grossly bloody stools and of fainting twice during the preceding 8 hours. Three years previously she had had a cardiovascular accident associated with hypertensive cardiovascular disease. Conservative therapy including blood transfusions seemed to control the bleeding. Active bleeding recurred during treatment, however. Diagnostic studies revealed only diverticulosis limited to the left colon. The patient's condition was extremely poor in spite of having received 14 pints of blood. Right transverse colostomy was done. Bleeding ceased, and the patient has had no recurrent hemorrhage during the 7 months since operation. She has refused to consider additional surgical treatment.

Among the 6 patients requiring emergency operation for uncontrolled hemorrhage, 4 had resections; 2, colectomies; 1, left colectomy; and 1, right colectomy. The 2 other patients had only transverse colostomy. Bleeding ceased in all but 1, a patient having only transverse colostomy. In this case the diagnosis was incorrect as the bleeding was subsequently found to be due to upper gastrointestinal disease. There were 2 deaths, 1 in a patient who underwent total colectomy and the other, left colectomy. In both, operation had been delayed too long, and both failed to rally from the operative procedures.

DISCUSSION

It is generally agreed that patients with bleeding from diverticular disease of the colon should be treated initially by conservative measures. Excluding the cases of mistaken diagnosis, of the 78 patients who had one or more episodes of hemorrhage from diverticular disease of the colon, 5 required emergency operation for uncontrolled bleeding. In addition, 3 died while being treated conservatively. Thus, 8 patients (10.3 per cent) failed to respond favorably to conservative treatment. Three of these 8 had been admitted one or more times for previous hemorrhage and had responded favorably to conservative treatment.

Elective operation, in cases of gross hemorrhage because of recurrent bleeding or when the diagnosis of carcinoma cannot be excluded, should offer satisfactory results, provided resection is extensive enough to remove the most diseased portion of the colon. Ample time is usually afforded to study and prepare the patient properly for operation. In general, if the disease is limited to one side of the colon, usually the left side, corresponding colectomy can be carried out. In a few instances the disease is so diffuse that total colectomy may be indicated. It must be emphasized that an area of demonstrable diverticulitis may not be the source of hemorrhage, and, when possible, the area of the colon most extensively involved with diverticula should also be removed.

The problem of what to do with the patient having uncontrolled hemorrhage is a serious one. Because of the present concept that all patients with bleeding diverticular disease should be treated initially with conservative methods, operation for uncontrolled bleeding is apt to be delayed and carries a high mortality rate. This is particularly true since these patients are usually old and have associated cardiovascular disease. Performing the desired tests on such patients may be difficult and hazardous. Even performance of proctoscopy or sigmoidoscopy is usually unsatisfactory in the face of active bleeding. Surgical exploration as a method of determining the location of the bleeding point is highly unsatisfactory. Even operative colotomy is of little value in localizing the site of bleeding. The difficulty of detecting the point of bleeding at operation can be further appreciated when one realizes that the mucosal erosion responsible for hemorrhage is generally so small that it escapes detection even in the resected specimen or at postmortem examination. If operation should become mandatory because of continued bleeding, the surgeon should make a thorough search for a tumor, polyps or an inflammatory process. If the diverticula are known to be limited to a portion of the colon, the involved area, usually the left side, should be resected. If the entire large intestine is involved and the bleeding point cannot be determined, there are several possible recourses: (1) closure of the abdomen and further dependence on conservative measures; (2) total removal of the abdominal colon; (3) blind resection of the most involved segment, usually the left side, and (4) diversion of the fecal stream by colostomy. In the face of continuous hemorrhage, something must be done. Cases 1 and 5 required re-exploration and resection for continued bleeding. Total colectomy in the unprepared intestine is a formidable procedure that is not desirable but may be unavoidable. Generally, the left side of the colon exhibits the most extensive diverticulosis and is the most likely to be the source of bleeding. The alternate method of diversion of the fecal stream by colostomy is not ideal. By this method the point of hemorrhage is not attacked directly but the method does offer several advantages in the extremely ill patient. Several writers[2-4] have reported cessation of bleeding by diversion of the fecal stream. In one of the 2 patients of the present series in whom this was performed, bleeding was controlled. The other patient was subsequently found to have upper gastrointestinal disease, which was causing the bleeding. If hemorrhage does continue after colostomy, the mere presence of the colostomy may localize the bleeding site to one side of the colon or the other and may permit more conservative resection. Also, it forms a ready site for introduction of intestinal antiseptics.

SUMMARY

A study of 20 patients treated surgically for gross hemorrhage from presumed diverticular disease of the colon was made. In 2 of these, the bleeding was subsequently found to be due to other disease.

Of 6 patients who underwent emergency operations because of uncontrolled hemorrhage there were 2 operative deaths. Bleeding was controlled in 3 of the remaining 4.

As hemorrhage from diverticular disease usually can be stopped by conservative treatment, it is generally agreed that these patients initially should be treated conservatively.

Elective operation in cases of gross hemorrhage, because of recurrence, or because of inability to exclude a diagnosis of carcinoma, offers satisfactory results provided the resection is extensive enough to remove the most diseased portion of the colon. This usually means left colectomy which can ordinarily be done in one stage.

Management of patients with uncontrolled bleeding requiring emergency operations remains an unsolved problem. The difficulty arises in recognizing those patients who are not going to respond favorably to conservative medical therapy at a time before they become prohibitive operative risks. The earlier the diagnostic studies and the earlier the performance of the operation, the better the surgical results which can be expected.

In patients whose general condition is too poor to permit resection, there is evidence to indicate that diversion of the fecal stream may tide the patient over the immediate danger of hemorrhage until a more definitive procedure can be performed.

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PERFORATED ESOPHAGUS: AN ACUTE EMERGENCY

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Esophageal rupture has always been regarded as a tragic accident. A rare condition many years ago, it is being observed more frequently as endoscopic procedures are being used more widely. This is reflected in the larger series that are being reported lately.

The present study follows the current trend and is concerned mainly with traumatic perforations of the esophagus most commonly observed today. A brief monographic outline is presented first, then is followed by the observations on 16 cases seen at Harper Hospital between 1947 and 1959.

A FEW FIGURES

In 1934 Jackson and Jackson[9] in their textbook on endoscopy refer to perforation as "an almost invariably fatal complication". Jemerin[10] records a 77 per cent mortality rate between 1925 and 1935 at Mount Sinai Hospital in New York, compared with 17 per cent from 1936 to 1947 at the same hospital. He also reports a higher mortality in those cases treated conservatively (68 per cent) against 26 per cent for those treated surgically. At the Mayo Clinic[15] the mortality rate fluctuated between 20 per cent and 66 per cent, depending on the site of the perforation (50 cases reviewed in 1950).

TYPES OF ESOPHAGEAL PERFORATIONS

The anatomic factor. The esophagus is a fragile organ that tolerates trauma poorly. The thinness of its wall, absence of serosa, relatively poor blood supply, and proximity to large respiratory and vascular channels, create serious problems in the treatment of its injury.

The anatomic narrowings are particularly vulnerable to perforation by the endoscope and foreign bodies. The cricopharyngeal and cardial narrowings carry the highest incidence of damage by endoscopy (54 per cent and 36 per cent at the Mayo Clinic; 70 per cent and 10 per cent in the series of Terracol and Sweet[15]). The aortic and the left bronchus narrowings are less commonly affected (10 per cent Mayo).

A very important factor is the configuration of the deep cervical fascia that surrounds the trachea, thyroid gland, carotids and esophagus in different compartments. The space left between the esophagus and the cervical spine that extends down the thoracic cavity allows gas, secretions or pus to accumulate when the cervical esophagus is perforated. This establishes ready access to the posterior mediastinum.[15]

Pre-existing pathology. Perforation of the esophagus is more likely to occur when lesions such as strictures, neoplasms, esophagitis, ulcerations and achalasia are present and instrumentation is being carried out. An instrument can easily break through diseased tissue or a weak dilated esophagus. Thirty per cent of the Mayo Clinic cases occurred during esophageal dilations, whereas at Harper Hospital, 25 per cent were due to dilators.

Size of the perforation. This is of great significance in the diagnosis, treatment and prognosis of esophageal perforations. The larger the rent, the more pronounced and urgent the symptoms, since greater amounts of esophageal secretions escape through the defect. Bisgard[3] has also taken into consideration the time factor and divides perforations into 3 groups: (1) slowly perforating lesions (erosions by tumors or some foreign bodies); (2) minute perforations (pins, fishbones, and so forth); and (3) gross immediate perforations (instrumentation, penetrating wounds, spontaneous ruptures).

In the first 2 types there is time to mobilize the body defenses so that treatment may be conservative in most instances. The 3rd group requires urgent surgical treatment.

The most common causes. The esophagoscope heads the list at the Mayo Clinic (32 per cent) and also at Harper Hospital (37 per cent); esophageal dilation is the next greatest offender (30 per cent at Mayo, 25 per cent at Harper). Foreign bodies stand at 26 per cent at Mayo and 12.5 per cent at Harper. The 4th place is occupied

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by gastroscopy (8 per cent) and 5th place by spontaneous ruptures (4 per cent), according to figures from the Mayo Clinic.[15]

There are numerous reports of smaller series or individual cases of esophageal rupture caused by foreign bodies,[3, 8, 13] penetrating agents,[7, 18] self-dilation[5] and spontaneous rupture,[12, 14, 15] but these are the rather uncommon types. Infections, aneurysms and neoplasms eroding through the esophagus are seldom seen in recent years. Ballin and Saltzstein[2] reported from Harper Hospital, in 1922, a case of esophageal perforation complicating right lobar pneumonia.

IMMEDIATE COMPLICATIONS

(1) Pneumothorax or pneumomediastinum, either one of which may be under tension and cause considerable respiratory embarrassment. (2) Infection may vary from a small abscess around the perforation to a large retropharyngeal abscess or phlegmon, mediastinitis or empyema. Chronic empyema and esophagopleurocutaneous fistulas are not uncommon as late complications. Shock may be present as the result of any of the aforementioned conditions.

DIAGNOSIS

With a history of recent instrumentation or trauma to the esophagus, esophageal preforation should be suspected and diagnosed early. Spontaneous rupture, however, passes unrecognized in over 50 per cent of the cases, according to Pate and his co-workers.[12] It should be suspected when a sudden increase of intra-abdominal pressure has preceded the onset of chest pain, dyspnea and collapse.

Whether the cervical or thoracic esophagus is perforated, pain is practically a constant first symptom, which is exaggerated by deglutition and respiratory movements. It is interesting to note that *chest pain* occurs even in the presence of injury to the cervical esophagus and in many instances is referred to as "a sharp pain between the shoulder blades". Neck pain is less commonly observed. Nausea and vomiting are not uncommon.

Cyanosis, dyspnea and signs of shock occur in all sizable perforations, particularly when a tension pneumothorax develops. Severe shock is a striking feature in large size perforations. Subcutaneous emphysema appears relatively early in many cases.

Fever, chills and the picture of a severe acute infection appear within a few hours. At this state, tenderness of the neck is frequently observed in perforations of the cervical esophagus. The neck may present subcutaneous emphysema and induration, but redness of the skin does not appear because the infection is locked within the deep fascia.

X-rays are of great value for the diagnosis and prognosis. Radio-opaque foreign bodies can be demonstrated in many instances. Gas can be found in the periesophageal tissues (Miningerode's sign). Other findings are: anterior displacement of the trachea, pneumothorax or pneumomediastinum, broadening of the mediastinum when there is mediastinitis, and respiratory complications. Contrast substances are used occasionally in the early phase of the perforation or perforation suspect. *Barium must not be used.* Lipiodol, Dionosil and similar substances are the safest to use for demonstrating perforations or fistulous tracts.

Esophagoscopy is contraindicated because of the danger of enlarging the perforation or perhaps creating a new one.

TREATMENT

Gross perforation of the esophagus is a very serious condition that requires rapid and energetic treatment. The basic steps recommended by most authors are as follows: (1) Combat shock when present (replenish circulatory volume and add vasopressor agents, as needed). (2) Drain pneumothorax or pneumomediastinum, especially if they are under tension. (3) Give parenteral antibiotics vigorously. (4) Rest the esophagus; no oral feedings. Atropine may be used to keep the pharynx dry. Insertion of a gastric tube may be done only at time of surgery, under direct control. (5) Perform early operation with 2 objectives in mind: (a) to close the perforation,[1] and (b) to drain the pus and secretions that so rapidly accumulate around the perforation. In many cases only the latter can be achieved, but this seems to be the most important and often the life-saving procedure. Mediastinitis and mediastinal abscess are the greatest dangers in perforations of both the cervical and thoracic esophagus. In perforations of the cervical esophagus the ideal is to get to the retroesophageal space before the infection has a chance to reach the mediastinum. Accordingly, the lateral cervical approach[15] is indicated (classi-

cal cervical mediastinotomy). In perforations of the thoracic esophagus, or when most of the pathology shows up within the thoracic cavity (which happens in low perforations of the cervical esophagus or late in the course of higher perforations of the cervical segment) the transthoracic approach is the best. If the diagnosis is made within the first 6 hours, primary closure of the rent should be attempted. But, if more than 6 hours has elapsed since the onset, drainage of the pleural space can be done under local anesthesia, a segment of rib resected, and a large tube connected to closed drainage bottle inserted. Blalock[4] has done primary resection of the perforated segment, with esophagogastrostomy in 2 cases of low esophageal perforations, with good results (preexisting pathology was achalasia in one and carcinoma in the other). A gastric tube is passed under direct control during the surgical procedure with the idea of keeping the esophagus at rest, the stomach empty and for tube feedings once the patient is ready for them. (6) Give no oral feedings for the first few days following surgery. Fluids and electrolytes should be given intravenously. Antibiotics are continued with the use of sensitivity studies whenever possible. Tube feedings are started by the 3rd day; the gastric tube is removed, and oral feedings started after the 7th day, as the patient's condition permits. (7) Maintain adequate drainage of purulent secretions; in many instances this will mean drainage of empyemas and new abscesses. (8) Begin ambulation early; encourage the patient and provide good nursing care.

In small perforations or in those that have developed slowly, conservative treatment can be carried out safely. Shapiro[16] has reported 6 cases (extended to 10 on verbal communication) of instrumental perforations of the esophagus treated conservatively with good results. He emphasized the time factor (immediate diagnosis, immediate treatment) and also the fact that the patient who has been endoscoped has a reasonably clean stomach, esophagus and oral cavity.

The conservative treatment follows the same principles of esophageal rest, intravenous fluids and antibiotics. Of the 16 patients at Harper Hospital, 2 were managed successfully by medical measures alone.

HARPER HOSPITAL EXPERIENCE

Sixteen patients with esophageal perforations have been treated at Harper Hospital within the antibiotic era from 1947 to 1959. Three of these were transfers from other hospitals. The results of our experience are discussed first and are followed by a brief presentation of 3 unusual cases.

TABLE 1

Esophagoscopy	6
Esophageal dilation	4
Foreign bodies	3
Surgical exploration	1
Endotracheal tube	1
Spontaneous	1
Total	16

TABLE 2

Site of Perforation	No. of Cases
Cervical esophagus	
Site undetermined	3
Zenker's diverticulum	1
Cricopharyngeal	1
Total	5
Thoracic esophagus	
Site undetermined	5
Upper thoracic esophagus	3
Lower thoracic esophagus	1
Aortic narrowing	1
At site of previous surgery for congenital tracheoesophageal fistula	1
Total	11

Etiology. Instrumentation was responsible for the majority of perforations, the figures being as shown in table 1.

Five of the esophagoscopies were done for foreign bodies that were too difficult to be removed. The dilations were done for one congenital and two chemical strictures. The foreign bodies that perforated the esophagus were: a table knife, a safety pin and a loop of wire. Surgical exploration on a nonresectable carcinoma of the esophagus led to perforation. An endotracheal tube placed inadvertently in the esophagus while giving general anesthesia accounted for an unusual perforation. There has been only one case of spontaneous rupture in this series.

Site of perforation. The majority of the perforations took place in the thoracic esophagus. The exact site could be identified only in 8 cases, as shown in table 2.

TABLE 3

Closed thoracotomy (drainage alone)	4
Exploratory thoracotomy	5
Posterior mediastinotomy	2
Tracheostomy and exploratory thoracotomy	1
Pulmonary decortication	1
Local intraesophageal incision and drainage	1
Empyema drainages	5
Excision of Zenker's diverticulum	1
Total of surgical procedures	20

Symptoms. Pain was a constant symptom. The most common regions affected were the neck, the chest retrosternally and the back between the shoulders. There was a definite history of trauma to the esophagus, with the exception of case 14, which was a spontaneous perforation.

Dyspnea, cyanosis and shock were present whenever tension pneumothorax developed. Eight of our patients had these problems, one with a perforation of the cervical esophagus. Fever and tachycardia were practically constant. Subcutaneous emphysema was observed only in 6 patients.

Diagnosis. Roentgen rays were of great value in the diagnosis and follow-up of these patients. They identified foreign bodies and showed pneumothoraces, and the fluid accumulations disclosed air in the retropharyngeal space, broadening of the mediastinum, and so forth. Lipiodol swallows were given in two instances demonstrating well the sites of perforation.

Treatment. The basic principles (treating shock, draining tension pneumothorax, rest to the esophagus and use of antibiotics) were followed in all cases. With the exception of 2 patients who had very small perforations and were treated conservatively with good results, the remaining 14 were subjected to surgical procedures, as listed in table 3.

In 2 patients the esophageal perforations were sutured at the time of surgery, but primary healing was not achieved in either one. Two patients who qualified for major surgery could not be explored because of their critical general condition, so closed thoracotomy was performed.

A true comparison between surgical and nonsurgical treatment cannot be made in this series because only those perforations judged to be small and localized were managed conservatively. There were only 2 of these, and both responded well to medical treatment.

The earlier the operation was performed, the better were the results obtained. All patients were treated according to the basic rules mentioned above. The only patient who, despite relatively prompt surgery, did not respond favorably, was a 57-year-old male who had swallowed a table knife and had a large perforation of the thoracic esophagus.

Feedings through a gastric tube were started by the 3rd to 5th postoperative day. Most tubes were removed by the 2nd week, and the patients were then gradually changed from clear fluids to full diet.

Morbidity and mortality. The morbidity can be judged indirectly by the length of stay at the hospital. The average was 33 days; the longest was 77 days; and the shortest, 4 days (although this patient was transferred to another hospital). Persistent pleural drainage, esophagopleural fistulas and empyema were the usual sequelae. Only 6 patients left the hospital with empyemas that required further drainage later.

There were 4 deaths in this series, a 25 per cent mortality rate. Two of these patients are described below. The 3rd, a 39-year-old Negro woman, was explored for nonresectable carcinoma of the esophagus behind the arch of the aorta. She sustained an esophageal perforation and died 3 days later while being treated by thoracentesis and antibiotics. The 4th patient, an 82-year-old white woman, had swallowed a peach stone that was removed through the esophagoscope with considerable difficulty (scope had to be introduced 4 times). Signs of esophageal perforation became apparent the following day and a posterior mediastinotomy through cervical approach was undertaken on the 2nd day. The patient deteriorated rapidly and died 2 days after surgical drainage.

THREE UNUSUAL CASES

Case 1. A 57-year-old white man, a known maniac depressive psychotic, who swallowed a table knife while at another hospital and was transferred to Harper Hospital on the same day (July 9, 1947). On arrival he was agitated, dyspneic and in restraints; blood pressure 97/70;

pulse, 120. Chest x-rays showed partial collapse of the left lung and a table knife in the mediastinum.

Immediate treatment was: drainage of pneumothorax, oxygen, intravenous fluids, and penicillin. The following day, as the patient's general condition was somewhat improved, a left thoracotomy was performed. The table knife was removed, and the posterior mediastinum and pleural cavity were drained; a Levin tube was inserted in the stomach. The site of perforation could not be identified because of the inflammatory changes and the large amount of purulent secretion in the posterior mediastinum and left pleural cavity.

This patient expired 4 days after surgery, after having had considerable difficulty with his pharyngeal and respiratory secretions. Traumatic tracheoesophageal fistula was suspected but could not be confirmed, as permission for autopsy was not granted.

Case 14. A 63-year-old white man who was admitted for "evaluation of anemia", was known to have hiatus hernia and esophagitis 6 months before admission. The day after admission he complained of epigastric distress and was put on a modified ulcer diet. On the 3rd day while eating his supper he had sudden severe transverse abdominal and back pains. Two hours later the pain was precordial, and he became dyspneic and cyanotic. The abdomen was boardlike rigid. Tentative diagnosis of acute pancreatitis was made, but dullness of the left lower chest was found. Chest roentgenograms showed bilateral pleural fluid and left tension pneumothorax.

His general condition deteriorated rapidly; there was high fever and tachycardia. Only closed thoracotomy for drainage of the tension pneumothorax and large doses of streptomycin and penicillin could be resorted to, in view of the critical general condition. The patient expired 2 days after the accident.

At autopsy the esophagus was found to be perforated 1.5 cm. above the cardioesophageal junction, toward the left pleural space. A superficial esophageal ulcer was also found, as well as the already known hiatal hernia.

It took about 24 hours to make the correct diagnosis on this case, and then it was too late for a major undertaking. This seems to be the situation with most spontaneous ruptures of the esophagus.[12]

Case 16. A 43-year-old white woman was admitted for vaginal hysterectomy. Although slightly obese, she was a good anesthetic risk. Under general anesthesia shortly after endotracheal intubation, she became cyanotic, the pulse was thready and the lungs could not be inflated by the anesthetist. The tube was found to have been inserted into the esophagus instead of the trachea. A smaller endotracheal tube was rapidly inserted and control of respiration was achieved. Meanwhile, subcutaneous emphysema of the neck and chest became apparent, and physical signs of right tension pneumothorax developed. Tracheostomy and insertion of drainage tube to the right pleural cavity were performed, and the patient transferred to the recovery room.

While in the recovery room, she became cyanotic again and chest x-ray films showed bilateral pneumothorax. Oxygen, intravenous fluids and antibiotics were being administered. Then the left pleural space was drained and the patient brought back to the operating room for right exploratory thoracotomy, the procedure being carried out 7 hours after the initial accident. The diagnosis of esophageal perforation was confirmed by a Lipiodol swallow before exploration. At surgery, a considerable amount of mucopurulent fluid and Lipiodol were found in the upper mediastinum. The site of the perforation visualized at the thoracic inlet of the esophagus being small and very hard to reach, it could not be sutured. A Levin tube was inserted in the stomach and drainage tubes were left in the upper posterior mediastinum proximate to the perforation, and in the right pleural cavity.

During the immediate postoperative course, fever and persistent left lung collapse were the main complications. These responded to antibiotics (streptomycin and Chloromycetin) and pleural suction. Tube feedings were started by the 3rd day, and at this time the tracheostomy tube was removed. A Lipiodol swallow on the 5th day showed the perforation to still be open. On the 6th day the Levin tube was withdrawn, and clear fluids were allowed orally despite the fact that a rather large amount of ingested fluid could be recovered through the tube in the right pleural cavity.

New Lipiodol studies on the 16th day showed no further leakage. There was marked clinical improvement. A localized right empyema was treated by the open method, and the patient was discharged on the 22nd day with the empyema drainage tube still in place. She had to return 11 days later for re-drainage of a right sacculated empyema. She has done well since.

SUMMARY

A brief review of the current literature on esophageal rupture is presented. Esophageal instrumentation and foreign bodies account for

most perforations. Diagnostic measures and treatment are considered. A group of 16 patients treated at Harper Hosptial is discussed; three uncommon case histories are presented individually. Perforation of the esophagus is an acute emergency. It must be recognized early and treated vigorously.

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A COMPARISON OF SHOCK FROM MASSIVE SOFT TISSUE WOUNDS AND SHOCK INDUCED BY THE INTRAVENOUS INJECTION OF GRAM-NEGATIVE ENDOTOXIN*

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In previous survival studies conducted at these laboratories evidence was presented which incriminated a "bacterial factor" in the lethality of experimentally produced shock from massive soft tissue wounds.[3, 4, 11, 12, 15, 16] Some of the more significant findings were as follows:

1. Fluid replacement alone (whole blood) was not sufficient to reverse the shock process.

2. Parenterally administered antibiotics prolonged survival time longer than did transfusion therapy.

3. Wide spectrum antibiotics prolonged survival in the wounded animal more effectively than did those antibiotics in which the antimicrobial activity was more limited.

4. A synergistic effect occurred when blood replacement and antibiotics were used in combination as therapeutic agents.

5. Lowering the quantitative fecal bacterial count had no effect on survival time unless the antibiotic was systemically absorbed.

6. Forceful irrigation of damaged muscle with antibiotics significantly prolonged survival time.

7. Local "refrigeration" of the wound significantly increased the survival time.

8. Indefinite survivals were realized when blood and antibiotics were administered and the wounds adequately debrided.

The mechanisms by which bacterial contamination affects survival of the experimental animal with massive wounds is not known. Septicemia as a cause of death could not be demonstrated in spite of repeated blood cultures taken at scattered intervals of the survival range of many animals. The "bacterial factors" involved in the irreversibility of the shock process in this experimental preparation theoretically could be bacterial toxins or some other toxic product of bacterial metabolism in the wound.

The qualitative bacterial flora of the wounds in this preparation was much the same as the bacterial flora seen in massive wounds in human beings during World War II and in the Korean conflict. Organisms representative of the fecal flora were the predominant wound inhabitants. These included representatives of the Gram-negative coliform group of organisms, the Gram-positive cocci, and aerobic and anaerobic Gram-positive spore formers.

PURPOSE

Because many Gram-negative organisms are included in the infecting populace and because the endotoxins of all Gram-negative bacteria appear to elicit similar if not identical pathophysiologic responses when given to experimental animals, it was decided to study the pathophysiologic changes in shock produced by the intravenous injection of lethal amounts of endotoxin from *Salmonella typhosa* organisms (strain 0-901), and to compare these changes with those observed in experimental shock from massive soft tissue wounds. These studies include gross and microscopic pathology, arterial and venous pressure changes, alterations in cardiac output, changes in blood volume, pressor responses to minute amounts of intravenous adrenaline, changes in chemical constituents of the blood, and paper electrophoretic analysis of the serum proteins.

METHODS

Angora wether goats 4 to 5 years of age weighing 80 to 120 lb. obtained from the Edwards Plateau in Texas were used for all experiments. The *S. typhosa* endotoxin was prepared by and obtained from the Immunology Division, Walter Reed Army Institute of Research. The acetone killing and drying method used in preparation of

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the endotoxin was reported in detail by Webster and associates.[20]

Although different samples of endotoxin were used in the course of the total group of experiments, all experiments in any single group were conducted with a single batch of endotoxin. The intravenous injection of 4 mg. of bacterial precipitate per kilogram of body weight suspended in 10 ml. of 0.9 per cent saline was found to be uniformly lethal to all animals. In all experiments the bacterial toxin was injected into the superior vena cava with an indwelling polyethelene catheter.

Shock from massive soft tissue wounds was produced by standard procedure described in previous publications.[12, 15] The bilateral detonation of tetryl pellets in the location described produced wounds which were lethal to the animal in a mean of 19.6 ± 5.7 hours.

Arterial and venous blood pressures were read directly from mercury and water manometers respectively. The cardiac output was measured by the dye method described originally by Moore and associates[13] and more recently modified by Shadle and his coworkers[17] using a cuvette densitometer. An electronic direct writing recorder was utilized to record the dye dilution curve. Plasma volumes were measured by isotope techniques using radioactive human serum albumin. Counting was accomplished on a scintillation well counting apparatus. The pressor response to 3 cc. of 1:20,000 Adrenalin injected intravenously was measured by use of a strain gauge and direct writing electronic recorder.

Blood chemistries including sodium, potassium, magnesium, calcium, phosphorous, blood urea nitrogen, nonprotein nitrogen, creatine, creatinine, and amino acid nitrogen and paper electrophoretic studies on serums of shocked animals were accomplished by methods which have been reported by R. W. Gillette of these laboratories.[3] Gross autopsies were done on the thoraces of all animals. Complete gross and microscopic postmortem examinations were done on occasional animals.

The animals were observed clinically and differences and similarities in the clinical patterns of shock from massive wounds and endotoxin induced shock were recorded.

TABLE 1

Summary of comparison in shock from massive soft tissue wounds and shock induced by the intravenous injection of Gram-negative endotoxin

	Shock from Massive Wounds	Toxin-Induced Shock
Clinical	Preterminal salivation Diarrhea, 5% Nystagmus (terminal), 5%	Preterminal salivation Diarrhea, 95% Nystagmus (terminal), 10%
Type death	Respiratory	Respiratory
Pathology	Pulmonary edema, 20% Pulmonary congestion, 100% Subendocardial hemorrhage, 90%	Pulmonary edema, 90% Pulmonary congestion, 100% Subendocardial hemorrhage, 90%
Arterial pressure	↓	↓
Venous pressure	Initial ↓ slight terminal ↑	Initial ↓ slight terminal ↑
Blood volume	↓ by ½ then → (slow decline) fatal outcome not affected by replacing and maintaining volume	↔ Maintained; hypovolemic animal more susceptible to action of toxin than normovolemic animal
Pressor response to 3 cc. 1:20,000 Adrenalin	Gradually decreasing response	Gradually decreasing response
Serum electrophoretic change	Slight rise A_1A_2 fractions	No change
Chemistries	BUN*, NPN,† creatine, creatinine ↑ Amino acid nitrogen ↔ to ↓ P, MG, ↑ NA ↔ CA ↓ K (terminal ↑)	BUN, NPN, creatine, creatinine ↑ Amino acid nitrogen ↔ to ↓ P, MG, ↑ NA ↔ CA ↓ K (terminal ↑)

* Blood urea nitrogen.
† Nonprotein nitrogen.

RESULTS

The manner in which death occurred had many points of similarity in both forms of shock under observation. In both groups of animals, death was immediately preceded by a semi-stuporous state during which the tongue protruded and sagged from the side of the mouth and heavy salivation was present. Clinical evidence of pulmonary edema was observed in both forms of shock terminally. However, clinical pulmonary edema was more severe as a terminal feature of toxin induced shock than it was in shock from massive soft tissue wounds. In both preparations a respiratory type death was a relatively constant feature, *i.e.*, breathing ceased several minutes before the heart stopped beating. In approximately 10 per cent of animals in both groups nystagmus was seen within ½ hour of death. Diarrhea was a constant feature of endotoxin-induced shock and in contrast was observed in less than 5 per cent of animals in which shock has been induced by soft tissue wounding techniques (table 1).

Arterial Pressure

Toxin-induced shock. The arterial blood pressure increased to hypertensive levels within 1 minute after the intravenous injection of a lethal amount of endotoxin, reached a maximum pressure within 3 minutes, and returned to normal values within 5 minutes after administration. The arterial blood pressure then dropped insidiously to hypotensive levels and continued to fall until death (fig. 1).

Shock from massive wounds. The arterial pressure fell immediately after wounding to hypotensive levels. After this drop the arterial pressure showed a tendency to stabilize around 50 mm. Hg. Immediately before death the arterial pressure dropped precipitously from the plateau level.

Venous Pressure

Toxin-induced shock. The venous pressure in toxin-induced shock paralleled the arterial pressure except terminally when there was a slight terminal rise in venous pressure. Within 1 minute after the intravenous injection of lethal amounts of endotoxin the venous pressure rises sharply to reach a maximal pressure at approximately 3 minutes postinjection. Subsequently, there occurs a gradual fall in the venous pressure to levels below normal. In most animals there was a slight terminal rise in the venous pressure (fig. 1).

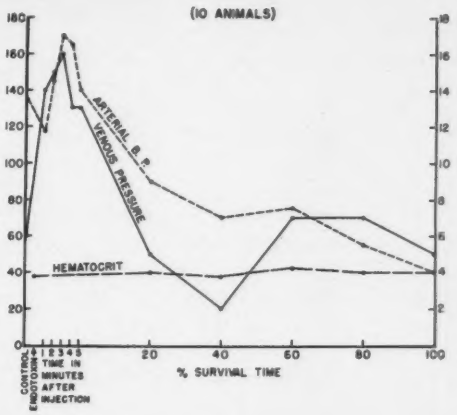

FIG. 1. Arterial pressure, venous pressure and hematocrit changes in endotoxin shock.

Shock from massive wounds. The central pressure fell after injury then recovered and reached a plateau of pressure. This pressure was maintained until approximately 30 minutes before death when a terminal rise occurred.

Blood Volume

The plasma volumes of 5 healthy goats were determined before the induction of shock by the intravenous injection of endotoxin. After the pressure of these animals had reached 70 mm. Hg, the plasma volumes were redetermined. In one of these animals (8541) an additional plasma volume determination was made when the pressure had dropped to 50 mm. Hg. The time interval which elapsed between determination no. 2 and determination no. 3 in this animal was 30 minutes. The maximal difference between initial and final determination in any animal was 110 cc., and that difference occurred between determination no. 1 and no. 3 in goat no. 8541 (fig. 2). Even this maximal difference, however, is well within the range of acceptable experimental error. In essence then it might be said that insofar as the determinations were carried, the plasma volume remains essentially normal in spite of a fall in blood pressure to hypotensive levels.

Cardiac Output

We made 57 cardiac output determinations in 14 animals subjected to detonation injury. In

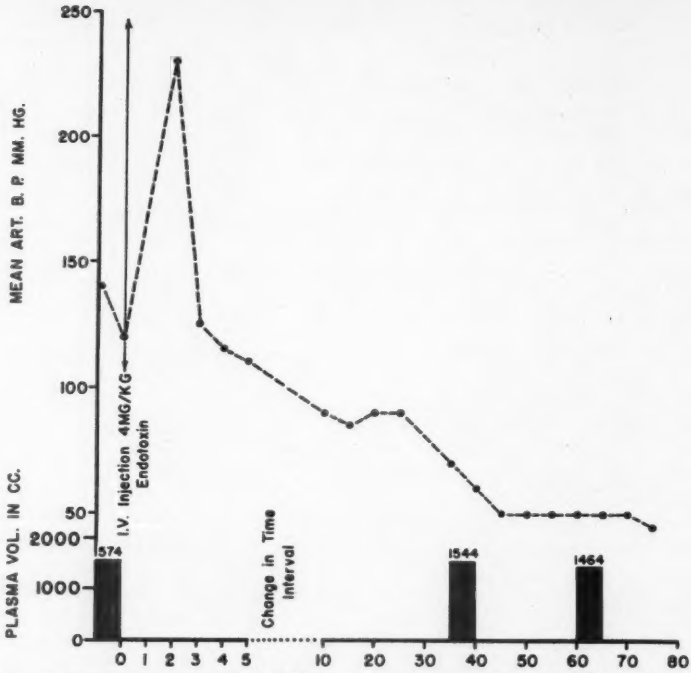

FIG. 2. Plasma volume of an animal in which hypotension was initiated by the intravenous injection of Gram-negative endotoxin. Note the fall in blood pressure in spite of normal plasma volume.

all 14 animals control outputs were measured before injury, and in all animals another determination was made within 15 minutes after injury. The remaining 29 measurements were scattered throughout the survival time of the animal.

In figure 3 the fall in cardiac output in this form of injury is graphically illustrated. The control values in 14 animals averaged 4723 cc. Immediate postinjury cardiac output averaged 3085 cc. in 14 animals. At 25 per cent of survival the cardiac output averaged 2895 cc. in 11 determinations. The mean value of 10 determinations at 50 per cent of the survival time was 2969 cc. and at 90 per cent of survival time in 9 animals studies was 2567 cc.

In toxin-induced shock, 20 cardiac output determinations were made on 10 animals, one control value and one value immediately after the blood pressure had fallen below 70 mm. Hg. The mean control cardiac output for this group of animals was 4714 cc. After toxin injection and hypotension (mean value 56 mm. Hg) the cardiac output fell to a mean value of 2957 cc. (fig. 4).

Response to Adrenalin

Four groups of animals were given minute amounts of Adrenalin intravenously (3 cc. 1:20,000) at 1- to 4-hour intervals, and the change in mean arterial blood pressure induced by Adrenalin recorded. In uninjured healthy animals, the degree of response remained essentially unchanged throughout the period of observation. Animals bled to 70 mm. Hg before the injection of Adrenalin responded much like the control animals except for a slight tendency to hyper-react to the vasopressor. Animals bled to 70 mm. Hg and given a lethal intravenous dose of endotoxin exhibited progressive decreasing response to Adrenalin as did the animals subjected to massive soft tissue wounds (fig. 5).

Irreversibility to Transfusion

We had previously reported that shock from massive soft tissue wounds could not be reversed

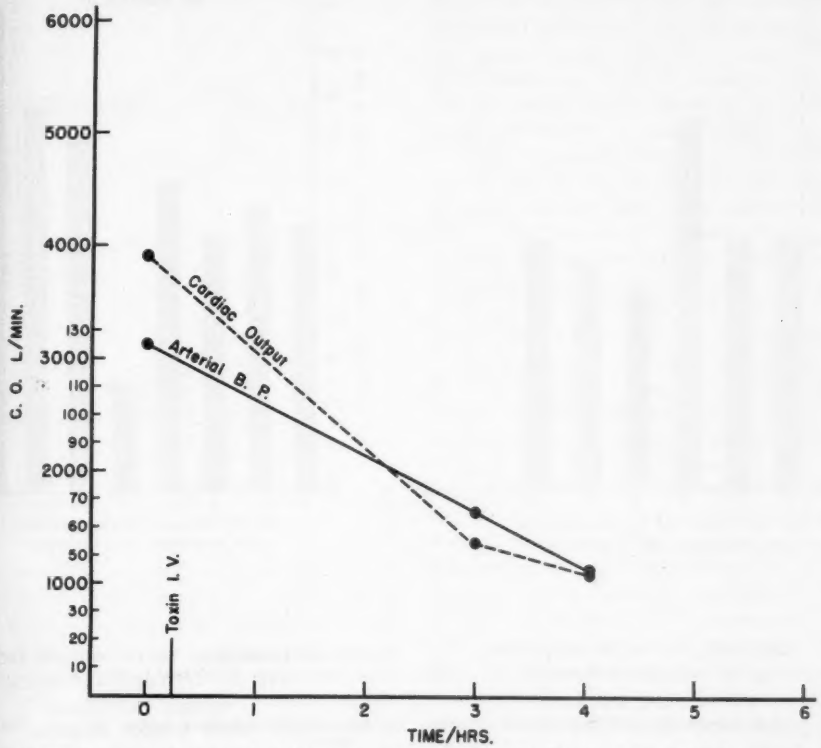

FIG. 3. Cardiac output and arterial pressure changes in a single animal in which hypotension was induced by the intravenous injection of Gram-negative endotoxin.

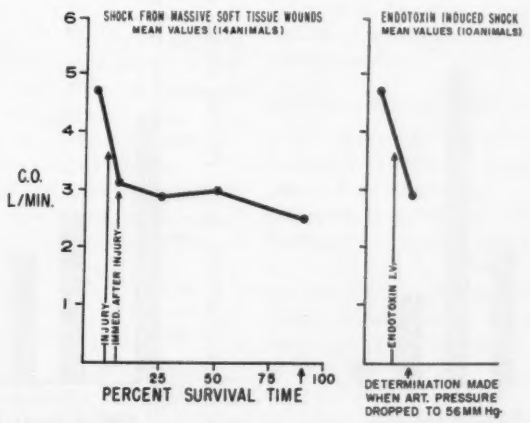

FIG. 4. Comparison of cardiac output in the two forms of shock under observation.

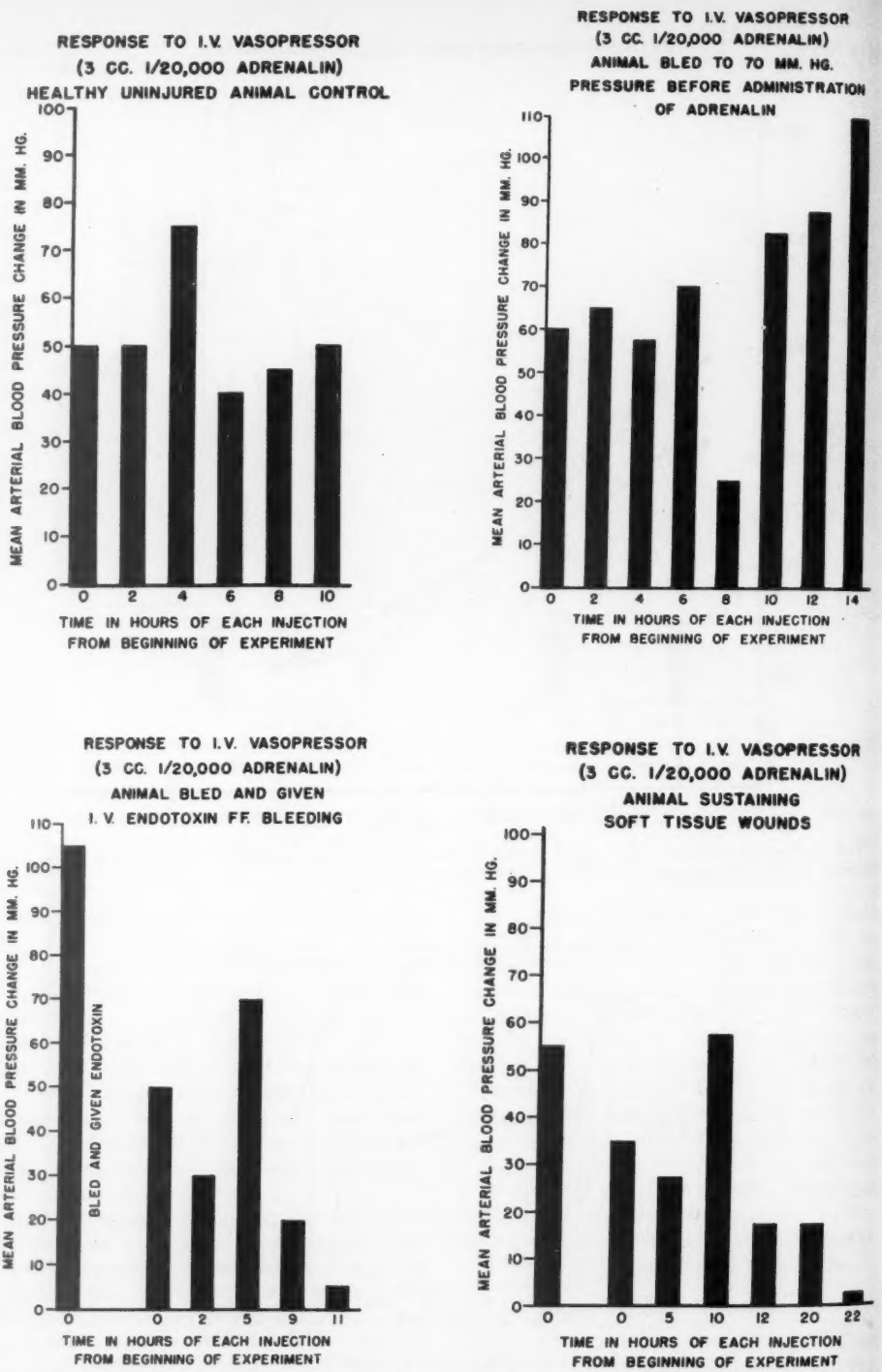
RESPONSE TO I.V. VASOPRESSOR
(3 CC. 1/20,000 ADRENALIN)
HEALTHY UNINJURED ANIMAL CONTROL
MEAN ARTERIAL BLOOD PRESSURE CHANGE IN MM. HG.
TIME IN HOURS OF EACH INJECTION
FROM BEGINNING OF EXPERIMENT
RESPONSE TO I.V. VASOPRESSOR
(3 CC. 1/20,000 ADRENALIN)
ANIMAL BLED TO 70 MM. HG.
PRESSURE BEFORE ADMINISTRATION
OF ADRENALIN
MEAN ARTERIAL BLOOD PRESSURE CHANGE IN MM. HG.
TIME IN HOURS OF EACH INJECTION
FROM BEGINNING OF EXPERIMENT
RESPONSE TO I.V. VASOPRESSOR
(3 CC. 1/20,000 ADRENALIN)
ANIMAL BLED AND GIVEN
I. V. ENDOTOXIN FF. BLEEDING
BLED AND GIVEN ENDOTOXIN
MEAN ARTERIAL BLOOD PRESSURE CHANGE IN MM. HG.
TIME IN HOURS OF EACH INJECTION
FROM BEGINNING OF EXPERIMENT
RESPONSE TO I.V. VASOPRESSOR
(3 CC. 1/20,000 ADRENALIN)
ANIMAL SUSTAINING
SOFT TISSUE WOUNDS
MEAN ARTERIAL BLOOD PRESSURE CHANGE IN MM. HG.
TIME IN HOURS OF EACH INJECTION
FROM BEGINNING OF EXPERIMENT

FIG. 5. A comparison of the pressor response of normal animals, animals bled to 70 mm. Hg pressure, animals in shock from massive wounds, and animals in endotoxin shock to minute quantities of vasopressor (3 cc. of 1:20,000 Adrenalin) administered intravenously.

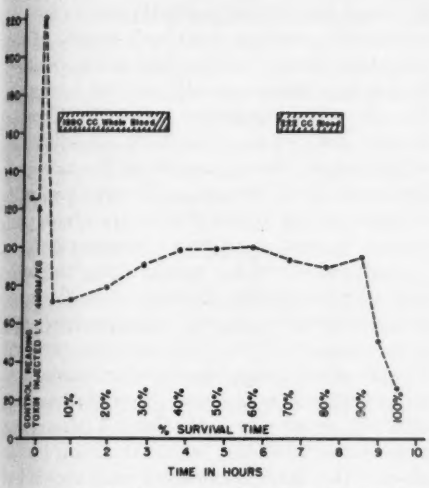

FIG. 6. A graph of average values illustrating the irreversibility of endotoxin-induced shock to the transfusion of whole blood.

when adequate amounts of whole blood were administered to the injured animal.[11] A series of 10 animals was given lethal injections of endotoxin. When the blood pressure of these animals fell to 70 mm. Hg, they were transfused with whole blood until the pressure rose to within relatively normal limits. Attempts were made to maintain the blood pressure at normal manometric levels with whole blood. As is apparent in (fig. 6) a graph of mean values, we were unable to reverse the shock process even though an average of 2112 cc. of whole blood were given to the animal. The mean survival time of the animals thus treated was 9.7 hours. This may be compared to a group of 9 animals given a lethal dose of endotoxin alone. The mean survival time of the control group of animals (without transfusion) was 11.6 hours.

Pulmonary edema in the transfused animals was much more severe than in the control group and indeed the transfusion of whole blood to these animals may have hastened their deaths.

Increased Susceptibility on the Hypovolemic Animal to Endotoxin

To determine whether or not hypovolemia increased the animal sensitivity to endotoxin a survival study was carried out. Ten control animals were bled to 70 mm. Hg blood pressure and maintained at this level of pressure for 1 hour. The average "bleed-out" necessary to accomplish the level of hypotension was 25.5 cc. per kg. body weight. Of these animals 6 lived for 72 hours and were sacrificed at that time. The remaining animals died at 2, 8, 38 and 44 hours, respectively. It is interesting to note that in the 2 animals dying early the bleed-out volume was 19 and 16 cc. per kg., respectively, and probably indicates that these animals had an initial blood volume deficit before bleeding. If, however, a mean survival time is calculated for this group of animals with 72 hours as the survival time of those sacrificed, the mean survival time of the group was 52.44 hours. A second group of 9 animals was given a lethal intravenous dose of endotoxin (4 mg. per kg. body weight). These animals were not subjected to hypovolemia. The mean survival time of this group was 11.6 hours. A third group of 10 animals was bled to 70 mm. Hg, maintained at this level for 1 hour and at the end of 1 hour was given a lethal dose of endotoxin intravenously. The mean survival time of this group of animals was 2.39 hours. The average bleed-out volume necessary to accomplish 1 hour of 70-mm. hypotension of this group of animals was 25.4 cc. per kilogram of body weight. When group 2 is compared to group 3, the decrease in survival time from 11.6 to 2.4 hours is statistically significant to the 0.01 level.

Biochemical Alterations

The changes in blood chemistries in endotoxin-induced shock parallel the change seen in shock from massive wounds. These changes have been reported previously by this group of investigators.[3]

Changes in Serum Electrophoretic Pattern of Serum

No significant alteration occurred in the electrophoretic pattern of serums from animals in which shock was induced by the intravenous administration of a lethal dose of endotoxin. This finding is in contrast to the percentage increase in the A_1 and A_2 fraction noted in the serums of animals dying of shock from massive wounds. These electrophoretic changes in the serums have been previously reported by R. W. Gillette of these laboratories.[4]

DISCUSSION

These results of these experiments indicate many points of similarity between endotoxin-

induced shock and shock resulting from massive soft tissue wounds. We have stressed previously the role of the wound in the development of irreversibility in the wound shock preparation. The combination of large amounts of devitalized muscle, clotted blood, and extravasated serum offer superior mediums for the growth of bacteria. Quantitative and qualitative bacteriologic studies reported by us have shown Gram-negative bacteria to be present in concentrations as high as 10^6 viable bacteria per gram of traumatized muscle.[16] Under these conditions it seems reasonable that Gram-negative endotoxins may be produced in significant quantities within the wound and possibly contribute to the development of the irreversible shock state.

However, the etiologic implications of these experiments must be designated as suggestive until such a time as more positive proof is forthcoming. In order to better define the possible role of endotoxin in the wound shock preparation it seems necessary to first prove that endotoxins are produced in lethal quantities and that lethal quantities are absorbed into the systemic circulation. In fact the importance recently attached to the role of endotoxins in many shock preparations must be received cautiously until more is known about the biochemistry and metabolism of these substances. Until these latter factors are better understood one cannot even be certain that the data from isotope tagging experiments is entirely accurate since it cannot as yet be proved that the radioactive tag remains attached to the lethal fraction or fractions of the endotoxin.

The hemodynamic data resulting from these experiments only tends to corroborate the experiences of other authors.[10, 21] Numerous workers in this field have emphasized the fact that the hemodynamic effects of endotoxin are best explained by an increase of the volume of blood in peripheral vessels. Cardiac output, arterial pressure and central venous pressures are diminished in the presence of normal total blood volume. Weil and associates[21] have shown that these phenomena are secondary to decreased venous return.

The basic modalities through which endotoxins exert their effect on the circulatory system are unknown. That small vessels are involved is suggested by the work of Algire, and associates[1] who observed the effects of a purified endotoxin (Shear's polysaccharide of *Serratia marcesens*) on normal muscle and neoplastic tumors in mice and reported capillary stasis with slowing of the venous and arterial stream. Zahl and associates[22] have shown hemorrhage and necrosis in tumors after the administration of endotoxin. Thomas showed that repeated endotoxin injections in rabbits caused cortical necrosis of the kidneys.[19] Production of the Swartzman phenomenon with endotoxin is well known.[18] All of the above phenomena suggest small vessel involvement.

Ebert and coworkers suggest that "the toxin may alter the elastic properties of small vessels permitting them to distend more completely at a given pressure. This effect could be mediated through direct damage to vascular endothelium or musculature or indirectly through humoral, metabolic, or nervous mechanisms. A second and more remote possibility is that the toxin has no effect on the elastic properties of small vessels but induces active veno constriction with subsequent rise of pressure and destruction of distal small vessels."

King and Wood[6] have recently shown that the pathogenesis of endotoxin fever was not (except under certain special circumstances) due to the direct action on the thermoregulating center but was mediated through endogenous pyrogens, presumably derived from polymorphonuclear leukocytes.

Working with an isolated heart lung preparation Kuida and associates[7] have recently presented evidence which suggests that the effects of endotoxin on the pulmonary vascular tree are mediated through the liberation of some agent or agents in the blood.

It is entirely possible and even probable that other pathophysiologic effects of endotoxins are mediated through other than direct pathways.

The recent work of Lindsey and associates[8, 9] and Noyes and coworkers[14] suggests a distinct correlation in this preparation between the quantitative lecithinase positive clostridial count in the open wound and survival time. Lindsey states that "the mechanism of death in these animals appears to be a combined effect of progressive loss in circulating blood volume, plus clostridial infection." In the light of the evidence these authors present, endotoxins would seem, at best, to play a minor role in the death of these animals.

The experimental data of Greisman[5] suggests that a combination of temporary plasma volume

reduction and the presence of clostridia in an open wound markedly increases the susceptibility of the experimental animal to a sublethal dose of endotoxin even though total blood volume has been replaced. When the open wound with its anaerobic inhabitants are deleted from the preparation, temporary reduction of blood volume does not result in increased endotoxin susceptibility. It is therefore possible that the lethal effects of clostridial infection and blood volume reduction are enhanced by or even mediated through an increased susceptibility to endotoxins.

The role of endotoxins, if any, in the production of irreversible shock in many experimental preparations is not clear and will probably remain obscure until definite biochemical identification can be accomplished.

SUMMARY

1. Experimentally induced shock from massive soft tissue wounds and from the intravenous injection of lethal amounts of Gram-negative endotoxins have been compared.

2. The clinical manner in which death occurred had many points of similarity in both forms of shock. Diarrhea and clinical pulmonary edema was a more constant feature of endotoxin shock than of shock from massive wounding.

3. The hemodynamic response to the shock provoking stimulus was identical in both forms of shock.

4. Biochemical alterations in endotoxin-induced shock parallel the changes seen in shock from massive wounds.

5. In contrast to the quantitative alterations in the A_1 and A_2 fractions of the serum globulin in response to mechanical injury, no electrophretic changes were seen in the serum protein of animals dying as a result of the intravenous administration of endotoxins.

6. An increased susceptibility to endotoxins was observed in the hypovolemic animal.

7. Endotoxin shock in these experiments could not be reversed by the administration of whole blood.

8. It is probable that the pathophysiologic effects of endotoxins are mediated by other than direct pathways.

9. The experimental evidence presented in this and previous manuscripts by the author is suggestive but inconclusive evidence of the role of endotoxins in the production of shock from massive wounds. It is possible that clostridial exotoxins may be partly or entirely responsible for the irreversible changes observed in the wound shock preparation.

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Editorial

EARLIER OPERATION IN DIVERTICULITIS

Elective surgery for patients with diverticulitis of the colon is a reasonable and safe procedure. When symptoms of diverticulitis recur, resection should be performed early, before serious complications develop. In approximately 90 per cent of cases—that is, the mild cases before complications occur—diverticulitis can be managed by conservative medical measures.

Diverticulosis of the colon occurs frequently. The incidence at autopsy is reported to be 30 to 40 per cent in individuals past middle age; two-thirds of patients 85 years or older have diverticula. In general, sex distribution is about equal. Males predominate slightly in the surgical group and show the highest percentage when serious complications ensue.

In a study of 294 cases of diverticulosis at the Lahey Clinic, Boles and Jordan[1] found that diverticula involved the entire colon in 33 per cent and the descending and sigmoid colon in 55 per cent; they were rarely found in the rectum. Diverticula may be the site of inflammation or other serious complications. Most of the complications that require surgical intervention arise in the descending and sigmoid colon. These authors noted progressive involvement in 70 per cent and complications in 40 per cent. In a series from the Massachusetts General Hospital, 92 per cent of patients requiring operation had inflammation or other complications arising in the descending or sigmoid colon.

The complications of diverticula include inflammation, hemorrhage, obstruction, perforation and fistula. Formerly, most operative procedures were staged procedures, such as drainage of an abscess, diverting colostomy and finally, resection, for advanced serious complications. These stage operations were associated with a relatively high mortality rate. Undoubtedly, defunctioning colostomy may be lifesaving in emergency situations when perforation, peritonitis or hemorrhage has occurred, and resection must be avoided when acute inflammation or an abscess is present. Over the past decade, however, the trend has been toward earlier resection with primary anastomosis before the disabling and serious complications of a progressive disease occur.

Elective resection with primary anastomosis can be performed with greater technical ease before obstruction or perforation occurs. Under present day methods of preoperative preparation, it can be carried out with practically no operative risk. The indications for surgery are clear cut; they include localized pain associated with recurrent fever and chills, tenderness, prolonged illness, repeated attacks of pain, leukocytosis, subacute colonic obstruction, perforation, fistula, dysuria and frequency, presence of a mass, hemorrhage, and difficulty in distinguishing between an inflammatory mass and carcinoma. With formation of an abscess or fistula, surgical treatment should always be considered before perforation occurs.

During the past two years (1958 and 1959) 48 patients at the clinic had operations for diverticulitis; 39 (81 per cent) had one-stage resection, with no deaths. Other clinics have reported increasing numbers of resections in one stage with a very low mortality rate. At the Massachusetts General Hospital, one-stage operations have increased from 35 per cent (1942) to 57 per cent (1951 to 1953). At the Mayo Clinic one-stage resections have increased from 13 per cent (1945 to 1949) to 43 per cent (1950 to 1954); in 1954, 57 per cent were one-stage resections.

The care of the progressively disabled patient with diverticulitis should be shared by the medical and surgical consultants. Operation should be advised early in many cases rather than waiting for the inevitable perforation, abscess and fistula or obstruction, with all the unfortunate consequences of delayed definitive operative procedures. Elective one-stage resection is both practicable and safe.

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Book Reviews

The editors of THE AMERICAN SURGEON *will at all times welcome new books in the field of surgery and will acknowledge their receipt in these pages. The editors do not, however, agree to review all books that have been submitted without solicitation.*

The Golden Scalpel. By SEYMOUR KERN. John Day Company, New York, 1959.

This tale about the unwholesome influences that the author thinks are affecting the practice of medicine, although specifically indicated as applying to a special locality and at a special period after World War II, by implication is an indictment of the medical profession. Not only the ethical shortcomings of individual doctors, but the attitude of institutions and organizations is pilloried. The efforts of a hospital to control the conduct and attitudes of a few independent and highminded individuals is pictured as the persecution of the "goodies" by the "baddies", an echo of the cries of the far-left wing against Congressional Investigating Committees and the F.B.I. as "witch hunters." The characters are pasteboard, and to compensate for lack of other qualities that might earn the book a favorable reception, it is written in the hard-boiled style of paper-backs—soaked in alcohol and seasoned with sex.

HARVEY B. STONE, M.D.

The Story of Dissection. By JACK KEVORKIAN, M.D. The Philosophical Library, New York, 1959.

This thin volume of 80 pages is designed to give a brief survey of the highlights in the evolution of dissection of the human body. It succeeds reasonably well in this purpose, but of necessity leaves the reader rather with the feeling of having read a catalog, which is perhaps unavoidable in view of the brevity of the book. The story is well maintained so far as continuity of theme and relation of the topic of discussion to the flow of human history goes. Although frequent reference is made to the difficulty dissection encountered because of various emotional and traditional sources of opposition, one gets the feeling that the writer, from his modern standpoint, is unable to understand these emotions, and hence does not give a revealing explanation of why necropsy was so slow in being generally accepted. No account is taken of the fact that not only the masses of the people, but the very persons most in need of the knowledge to be gained only by dissection—the doctors of medicine and the priests who so often functioned as physicians—were themselves inhibited by the same influences that affected the general population. Regardless of this minor failure of clarification, the book is well suited to the needs of students and those seeking a summary history of human dissection.

HARVEY B. STONE, M.D.

Experimental Surgery, By J. MARKOWITZ, J. ARCHIBALD AND H. G. DOWNIE, Edition 4. The Williams & Wilkins Company, Baltimore, 1959.

The new, fourth edition of this most valuable work represents a thorough general revision of the previous volume and considerable additional material, especially in the form of chapters on the prostate gland, hypothermia, and the nervous system, as well as much extension of the treatment of vascular surgery and tissue transplantation. Those familiar with earlier editions need no recommendation of this one. For all others interested in research in physiology, for teachers of surgery, undergraduate or advanced, for veterinarians, and for clinical surgeons, either general or in the subspecialties, the book can be most useful.

In addition to a huge factual content (931 pages), and a profusion of excellent illustrations, the book is written in readable, sophisticated English, with a general philosophic tone, lightened by frequent flashes of humor, and full of plain common sense. The epilog deals effectively with the presently active discussion of what constitutes a good teacher. To the mind of the reviewer, the opening paragraph should be required reading for every teacher of surgery in medical schools and hospitals, and particularly for the directing members of the specialty boards of surgery and its subdivisions. It reads as follows:

"We have often heard graduate students of surgery, in attendance at good schools of this art, bemoan the fact that so little opportunity is given them to learn the craft of surgery. It is not the best course in surgery to insist on postgraduate training in pathology, physiology, biochemistry, anatomy and then to let the student hold a retractor for his final year of the course, and do a few standard operations. This is to insist on a proper training in everything but surgery. It is beside the point to defend this policy on the grounds that surgery is founded on the fundamental sciences, for every medical student is well grounded in these, and to demand a post-graduate knowledge of them at the expense of surgical craftsmanship is to neglect emphasis where it is much needed. It must be obvious that the combined presence at an operation of the professors of anatomy, physiology, pathology, and clinical diagnosis would not help a licensed physician operate for ruptured appendix or a toxic goiter."

This greatly needed to be said, and could not be said better.

HARVEY B. STONE, M.D.

Bone Tumors. By LOUIS LICHTENSTEIN. Edition 2. C. V. Mosby Company, St. Louis, 1959.

Very few clinical surgeons ever in a life time get a chance to review the tumors which occur in and around bones sufficiently enough to make generalizations and critical evaluations. Only those who have, so to speak, specialized in bone pathology see enough clinical material to evaluate it adequately. However, even in some instances these specialists cannot make definite statements. This book is written primarily for the clinical surgeons and orthopedists who are, from time to time, called upon to treat the tumors of bone. The book is well written and as a whole covers the rather confusing field of bone tumors, benign and malignant, quite adequately and succinctly. The personal opinions of the author have been kept at a minimum which to a great extent makes it easier reading.

The bibliographies at the end of each chapter are quite adequate and should serve as a starting point for future, more intensive, study of any individual subject. There is enough clinical discussion to make the book quite interesting to the clinician and enough descriptive pathology and cytology to make it comprehensive without being too abstract. What makes this presentation so interesting is not that there is anything particularly new but in the way that this rather vague, ill-defined, poorly understood branch of oncology is presented. This book, I feel, certainly deserves a place on the shelf of any general or orthopedic surgeon.

JOHN J. TANSEY, M.D.

The Care of Minor Hand Injuries. By ADRIAN E. FLATT, M.A., M.D., F.R.C.S., C. V. Mosby Company, St. Louis, Mo.

The relatively short volume of 266 pages entitled *The Care of Minor Hand Injuries* by Adrian E. Flatt is specifically intended to be a primer in the surgical treatment of hand injuries. The work is designed for the student of surgery as well as the clinical practicing and industrial surgeon who may be required to treat the traumatized, burned, or infected hand. By "minor" hand injuries, the author implies those with "a relatively small amount of tissue damage, suitable for out-patient care, and with a predicted freedom from post-operative complications."

Dr. Flatt has drawn from his wealth of experience in the first 4 chapters to present the important general principles of good care including surgical techniques of wound closure, functional anatomy of the hand, some basic principles of hand surgery, and an arbitrary although excellent classification of hand injuries based upon the clinical examination. The second section of the work contains 11 chapters devoted to the diagnosis, surgical techniques, and aftercare of specific hand injuries. The author emphasizes the rapid return of the injured to full employment by prompt definitive care of the injured part and a minimum of postoperative sequelae. The techniques are presented in detail, clear and readable; the methods have withstood the tests of time.

The wide use of skin replacement lends itself to an excellent description of grafting and flap transfer procedures. The chapters on fractures and joint injuries are of special interest and are marked by simplicity. The volume does not undertake the reconstructive surgery of the defunctionalized and extensively injured hand other than the immediate care.

Many excellent photographs and schematic illustrations are contained within the text; some of the procedures are illustrated in a progressive sequence in adequate detail with concise explanatory captions. The pre- and postoperative photographs illustrate the excellent functional and cosmetic results which can be achieved.

The house officer assigned to the emergency theater will find the volume of distinct value in the fundamentals as well as the specific techniques in hand care. The occasional hand surgeon has here a ready reference volume with sufficient repetition to make reading of each chapter a complete care program without reference to the preceding chapters. Some dogmatism is unavoidable in a volume of this type. The text is well indexed, and for further reading representative references are grouped under the chapter heads in the latter pages of the volume.

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